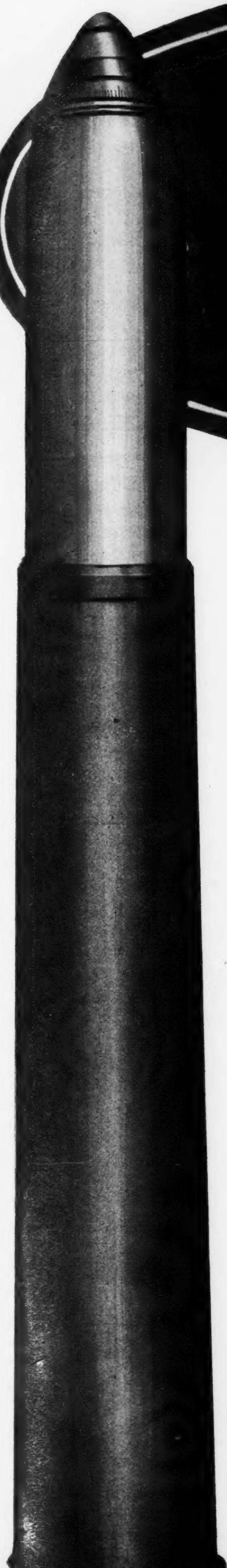
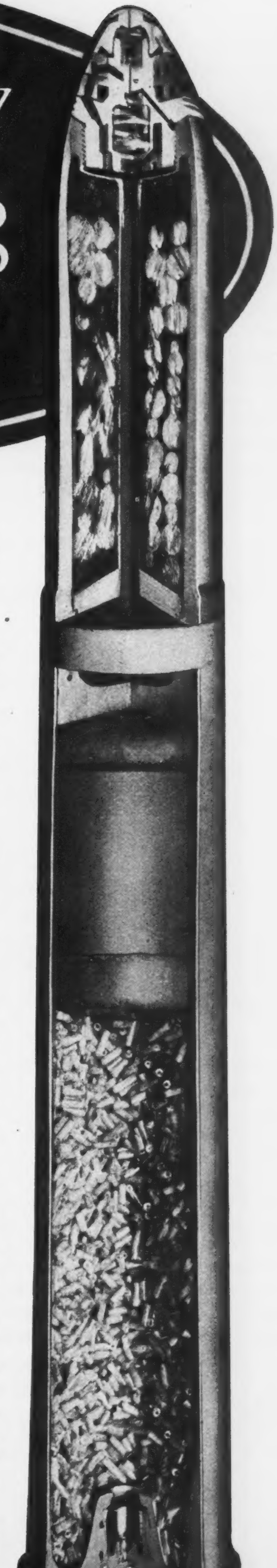


# Loading and Assembling Time Fuses[1]

by G. C. WHITE[2]



**The time and percussion fuse must be made very accurately and must be carefully adjusted to insure absolute reliability; this requires the use of special gages, fixtures, and testing apparatus. The complete equipment of a fuse loading and assembling plant is described in this article, which first explains in detail how a fuse operates and then takes up each step relating to fuse loading in the order in which the work is actually done.**

WHILE much has been written about the machining operations involved in the manufacture of time fuses, the assembling and loading has not received so much publicity. The practice in a loading plant may not seem to be as interesting, from a mechanical viewpoint, as manufacturing the different parts; but, as a matter of fact, the various operations and tests performed in a fuse plant must be done carefully and accurately and require the use of some very ingenious mechanical equipment. Before considering in detail the successive steps in the loading of time fuses, the particular design of time fuse (No. 80, Mark VII) to which this article refers will be described.

This fuse, which is shown in Figs. 1 and 2, is the combination time and percussion type such as is used on shrapnel shells. The fuse is so arranged that it regulates the length of time that elapses between the instant that the shell is fired and the explosion. The main body *A* of the fuse is provided with a cap *B* and two timing rings *C* and *D*. Within the cap there is a time pellet *E*, which contains a detonator and is held in the position shown, before firing the shell, by the flanges *F* on the stirrup spring. Just beneath the detonator there is a needle or firing point *G*. At the instant that the shell is fired, time pellet *E*, owing to its inertia, flies backward relative to the other parts of the fuse, so that the detonator strikes pin *G* and is discharged. Instantly the flame passes out through the flash hole *H* in the fuse body and the flash hole *I* in the upper ring (which contains powder) and ignites a train of powder which is tightly compressed in the groove or channel *J* of the upper ring. When this train of powder has burned around to a point opposite flash hole *K*, another powder train *L* in the lower timing ring is ignited. As soon as this second powder train has burned to a point opposite hole *M*, which is filled with a powder pellet, the flame is rapidly transmitted to the base charge, and thence, through a central tube, to the bursting charge in the base of the shell.

The time that elapses between the firing of the shell and its final explosion may be varied by changing the position of the

[1] For additional information relating to the manufacture of time fuses, see "Manufacturing Time Fuse Rings," in MACHINERY, March, 1918, and articles there referred to.

[2] Address: 1826 Park Ave., Montreal, Canada.

lower timing ring relative to the main fuse body and the upper ring. If we assume that flash holes *H* and *I* are in direct line with *K* and *M*, the fuse would then be set for the minimum length of time and the explosion of the shell would occur almost at the instant of firing. By turning the lower timing ring *D* so that the flash hole *K* is some distance from holes *H*, *I*, and *M*, it is necessary for the train of powder in channel *J* to burn around in one direction until hole *K* is reached, and then back in the opposite direction to opening *M* before the shell explodes. This adjustable timing ring is set by means of graduations which indicate seconds of time. For instance, if it is estimated that the shell should explode within ten seconds after firing, the lower timing ring is turned until the index line on it is opposite the ten-second graduation line on the flange of the fuse body.

If for any reason the timing arrangement should fail to operate, or if the shell should accidentally strike some object of sufficient mass to arrest its motion suddenly, the shell would be exploded upon impact by the p rcussion pellet *N*. This pellet, like the one previously referred to, contains a detonator, and it is normally held in the position shown in the illustration by spring *O* and the flanges *P* on the stirrup spring. At the same time that the pellet strikes the needle *G*, flanges *P* of percussion pellet *N* are straightened out by the ferrule or sleeve *Y*, which, by reason of its weight or inertia, is forced backward over flanges *P* at the instant the shell is fired. The percussion pellet is now ready to be effective whenever the flight of the shell is retarded sufficiently to enable the pellet to overcome the resistance of the coil spring *O*. For instance,

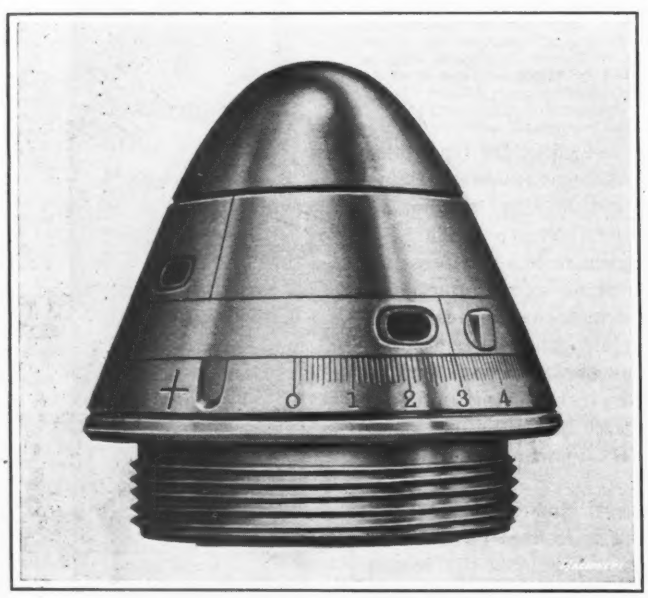



Fig. 1. Time and Percussion Fuse

if the movement of the shell were suddenly arrested, the momentum of pellet *N* would carry it forward, thus firing the detonator as it came into contact with the end *Q* of the firing pin. The flame then passes down through the center of the pellet to the base charge and central tube previously referred to and then to the base of the shell. It should be mentioned that the channels *J* and *L* in the timing rings do not form complete circles. When the solid portions between the ends of the channels are opposite holes *H*, *I*, and *M*, the fuse is then set in the safety position; the line on the lower ring is then opposite the + on the body flange. Beneath the flange of needle *G* a lead washer is provided to make sure that the flash or flame will not pass straight through the fuse to the base charge and cause a premature explosion. The felt washers *U* and *V*, which are placed between the rings, serve as gaskets.

Each time ring has an escape hole and vent which connects the initial end of the powder train with the exterior or the atmosphere. The oblong slots seen in the rings of the fuse illustrated in Fig. 1 are the escape holes. Each of these holes contains a powder pellet, which is covered and enclosed by a thin brass disk. When the initial end of the powder train in the upper ring is ignited, the powder pellet in the escape

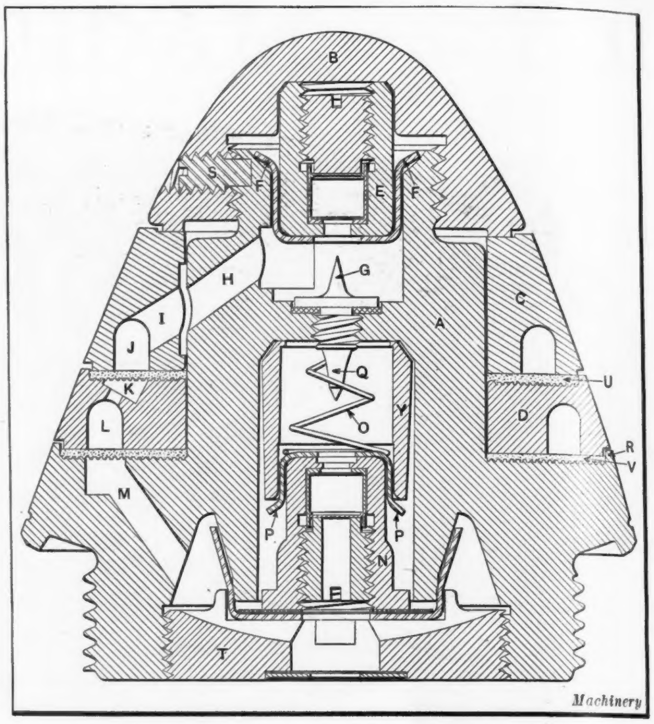



Fig. 2. Sectional View of Time and Percussion Fuse

hole burns rapidly until the pressure is great enough to blow out the disk. The train of powder is then in direct communication with the atmosphere, so that it burns and does not explode. If there were no vent, the powder composition in the groove would explode and the timing quality of the fuse would be eliminated.

### Drilling and Routing Operations on Rings

The operations performed at the loading plant are principally on the top and bottom timing rings (*C* and *D*, Fig. 2), and for that reason these rings will be considered first. Before loading with powder, certain machining operations are performed which will be described. The rings are first drilled at points corresponding to the ends of channels *J* and *L*, and a hole is also drilled in each ring, which is used as a locating point for all subsequent operations. The jig used for drilling these holes in the upper timing ring is illustrated in Fig. 3. It is necessary to have these holes in a certain relation to the elliptical escape hole in the side of the ring, and the work is held in the right position by a plunger *A*. This plunger engages the escape hole and the end is rounded off and made tapering so that it will easily enter the hole. When loading the jig it is turned over. Nut *B* is loosened and wing *C* is swung back, thus allowing the timing ring *D* to be inserted. Girls can drill 300 rings per hour. The diameter of the hole is 0.138 inch, and the depth, 0.188 inch. The drill spindle runs at 3000 revolutions per minute. It is necessary to regrind the drills after drilling from 800 to 1000 rings. The

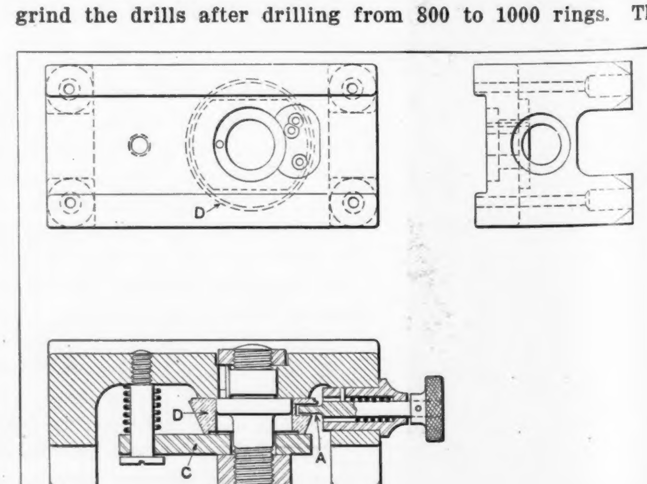



Fig. 3. Jig for drilling Holes at Ends of Powder Train Channel and also "Locating Hole"

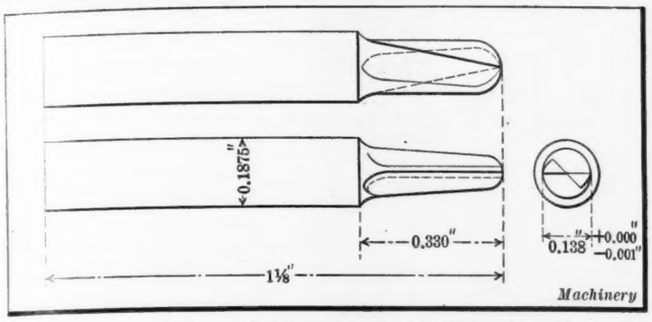



Fig. 4. Cutter used for milling Powder Train Channels

drills have been found to cut better if the lips are ground so that they will have no rake.

Any burrs that may have been formed, especially by dull drills, are next filed off and the lighting lines are scribed or cut. These lighting or index lines will be in line with the centers of the flash holes; the flash holes are drilled later. The line on the upper ring is used to locate it when drilling holes for the "securing pins" which hold this ring permanently in one position. The line on the lower ring is used for setting the fuse. Bench milling machines are used to cut these lines, the rings being mounted upon angle-blocks and fed under a fine cutter. The channels or grooves in the timing rings are next formed by a routing operation. One operator runs two Gorton machines and the channel is cut to the full depth in one passage of the cutter. The cutters used for this work are made of drill rod and are of the form illustrated in Fig. 4, which shows two views of the same cutter. This cutter is used to rout a groove of a width not less than 0.137 inch and not greater than 0.139 inch. No cooling compound is used for this operation and the average life of a cutter is 300 rings. The spindle speed for this routing operation is 8000 revolutions per minute.

The composition channels are now covered with a lacquer consisting of 1 pound of shellac, 8 ounces of turmeric, and 8 pounds of methylated spirits. The burrs caused by the routing operation are removed from the face of the rings by a disk grinder. The timing rings are now inspected for diameter, concentricity, and width and depth of the channel formed by routing. The gage used for testing the depth is illustrated at *A* in Fig. 5. The pin which does the gaging passes through an adjustable bushing that is provided to compensate for wear. It is surprising how fast a gage of this type will become worn. The adjustment of the gage is necessary after testing approximately 90,000

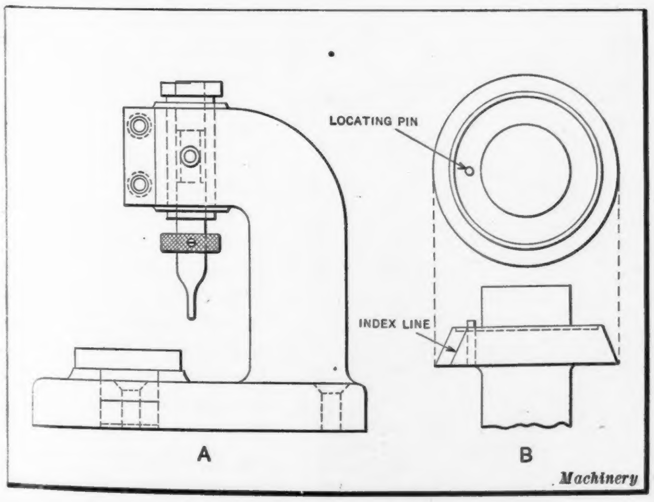



Fig. 5. (A) Gage for testing Depth of Powder Train Channel. (B) Gage for testing Location of Index Line on Fuse Ring

rings. The gage used for testing the position of the index line on each timing ring is illustrated at *B*. The timing ring is located in the right position relative to the gage by the pin shown, which engages the locating hole previously drilled by means of the jig shown in Fig. 3. The labor cost for preparing each ring for loading is 0.7237 cent, and is distributed as follows:

| Operation | Cost, Cent |
|---|---|
| Drilling (three holes) | 0.1125 |
| Marking | 0.0225 |
| Routing | 0.2250 |
| Grinding | 0.0225 |
| Cleaning | 0.0375 |
| Inspecting | 0.1575 |
| Drilling land | 0.0225 |
| Mechanics (two operating) | 0.0750 |
| Mechanic (repairs) | 0.0375 |
| Compound man | 0.0112 |
| Labor cost per ring | 0.7237 |

### Preparation of Powder for Fuses

After the preliminary machining operations referred to, the rings are sent to the loading department, which is kept at approximately a constant temperature by means of humidifiers

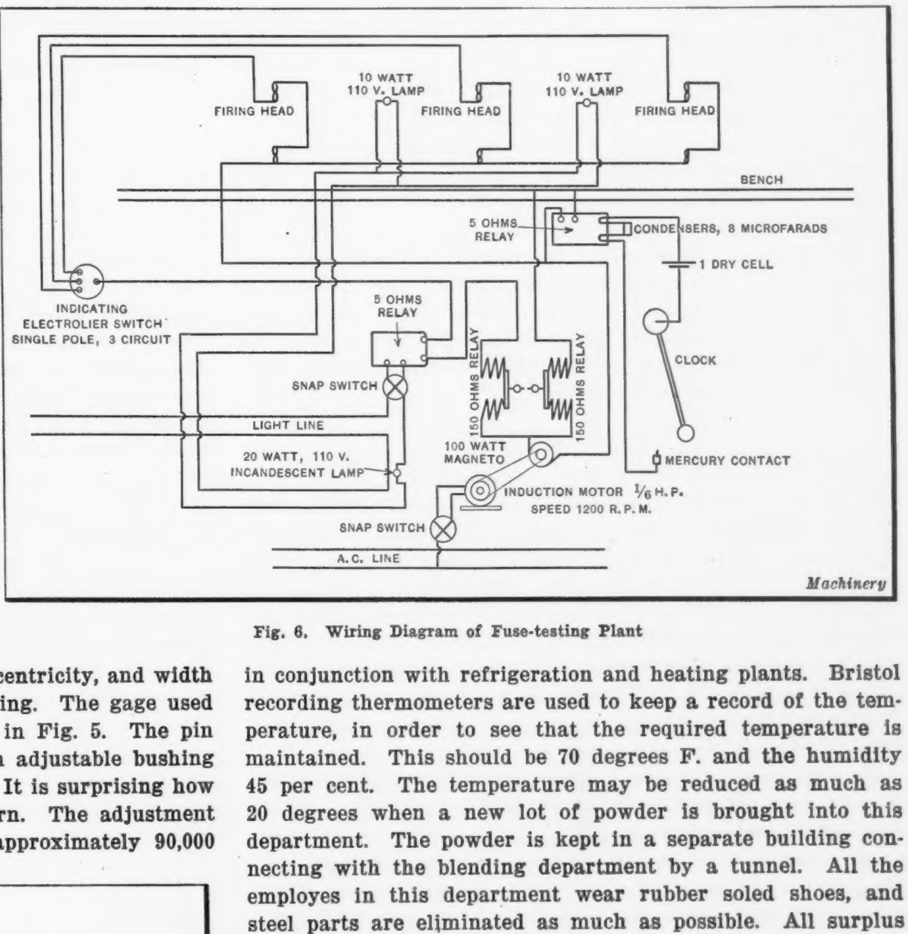



Fig. 6. Wiring Diagram of Fuse-testing Plant

in conjunction with refrigeration and heating plants. Bristol recording thermometers are used to keep a record of the temperature, in order to see that the required temperature is maintained. This should be 70 degrees F. and the humidity 45 per cent. The temperature may be reduced as much as 20 degrees when a new lot of powder is brought into this department. The powder is kept in a separate building connecting with the blending department by a tunnel. All the employes in this department wear rubber soled shoes, and steel parts are eliminated as much as possible. All surplus powder is collected by means of vacuum machines, the fan motors of which are located outside to avoid danger from any sparking of the motor. The powder for the fuses is tumbled and mixed in a wooden box which contains wooden balls; then it is passed over riddles, and smaller quantities are placed in covered receptacles made of copper or brass. The samples obtained in this way are next tested for burning and the results carefully noted and recorded.

### Testing Burning Time of Fuses

To test the powder, sample timing rings are loaded and the fuse is assembled. An apparatus known as the "chronoscope" (manufactured by F. G. Street, 60 Broadway, New York City) is used to obtain and record the burning time of the fuses. This apparatus consists of the recording machine illustrated in Fig. 7 and the firing heads shown in Fig. 8. Two of these firing heads are located at a reasonable distance from the recording machine and are connected to it by electric wiring.

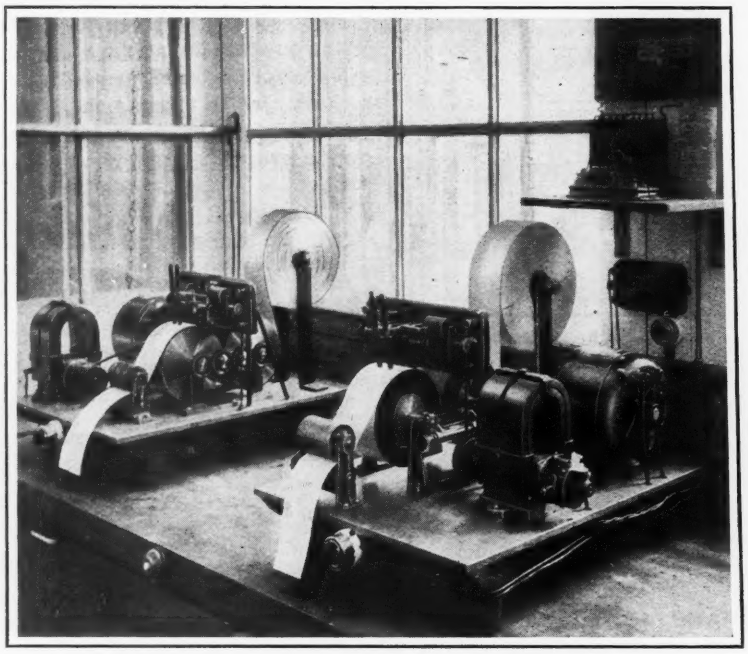


Fig. 7. Machine used to record Burning Time of Fuses

A laboratory clock is also connected by wiring with the recording machine. The fuse to be tested is placed in a firing head. The fuse cap (*B*, Fig. 2) has a hole bored through it to permit inserting a steel plunger that can be used for exploding the detonator. The fuse is screwed into the firing head beneath a suspended weight, which falls at a given instant by the releasing of a clutch. When the weight falls and strikes the steel plunger, the detonator explodes and instantly the paper tape of the recording machine begins to pass through the machine and the clock records on this tape each second of time. The explosion of the detonator also ignites the powder train in the upper timing ring, and, when the bottom ring escape hole disk blows out, it strikes a conveniently arranged plate which breaks the contact, thus giving a record of the burning time for the upper ring. This record is on the paper tape referred to. The lower timing ring burns until it ignites the magazine charge, which breaks another contact, so that a record of its burning time is also obtained. A fuse may be tested in approximately one minute, and it is claimed that the burning time obtained is within 1/100 of a second of the exact time. The time of burning is scaled off from the tape and corrections are made for atmospheric conditions. The wiring diagram of the fuse-testing plant is illustrated in Fig. 6.

### Loading Fuse Rings

If the tests are satisfactory, a certain number (or "lot") of fuse rings are sent to the loading department. The ten men in the loading gang load approximately 4000 rings in nine hours. The presses used in connection with this work have a capacity of 75,000 pounds and are located at the curved end of the U-shaped loading table. The work is divided into assembling and disassembling the loading tools and distributing the powder. All powder is blended in accordance with the results obtained by the tests, and is sent to the loading rooms in relatively small brass-covered containers. The distribution of the powder into the channel is accomplished by means of the funnel shown at *A* in Fig. 11. This operation is important, as the powder must be uniformly distributed and of the exact quantity required, which is determined by using a measure that holds the correct amount. If the powder, which is fine like flour or meal, as the case may be, is packed or heaped up too much in the measure, there will be a variation in the loading, because the presses are set to compress to a certain load, which depends upon the amount of powder. Variations in distribution will produce hard and soft spots of powder, or broken trains, etc. The total scrap from this operation is about 3 per cent. The powder funnels should preferably be made of nickel, because the powder will not adhere to the sides of the funnel.

The powder train in the upper timing ring is subjected to a pressure of 40,000 pounds when loading, and the train in the lower ring, to a pressure of 46,000 pounds. An Olsen testing machine arranged for this work is shown in Figs. 9 and 10. This machine applies the necessary pressure, and it has a scale or weighing mechanism to indicate the weight. The ring which is to have its upper train compressed is inserted in a loading tool, which is inserted in the press through the opening at *A*, Fig. 9. The machine shown is arranged for hand feeding, but some of the presses for fuse loading are equipped with automatic feeding mechanisms. The loading tool is inserted beneath a yoke which is forced downward by screws. These screws are rotated through a train of gearing and a silent chain drive connecting with the motor shown in Fig. 10. When the loading tool is properly located beneath the yoke that applies the pressure, the operator engages a clutch by means of hand-lever *B*, Fig. 9, and when the weighing scale shows that the required pressure has been applied, this driving clutch is disconnected. The automatic press feeder (manufactured by F. G. Street, 60 Broadway, New York City) is controlled by two small levers at the outer edge of the table. If both these levers are not compressed, the die or loading tool is not carried under the press. After the die is inserted in the carriage of the feeding mechanism, the operator's hands, after leaving the die, compress the two levers, thus releasing the carriage, which conveys the die to the proper position in the press. After pressure has been applied, the carriage moves outward and remains in the outer position until another die is placed in it, when the operation is repeated. The opening through which the die passes is automatically opened and closed by a safety door.

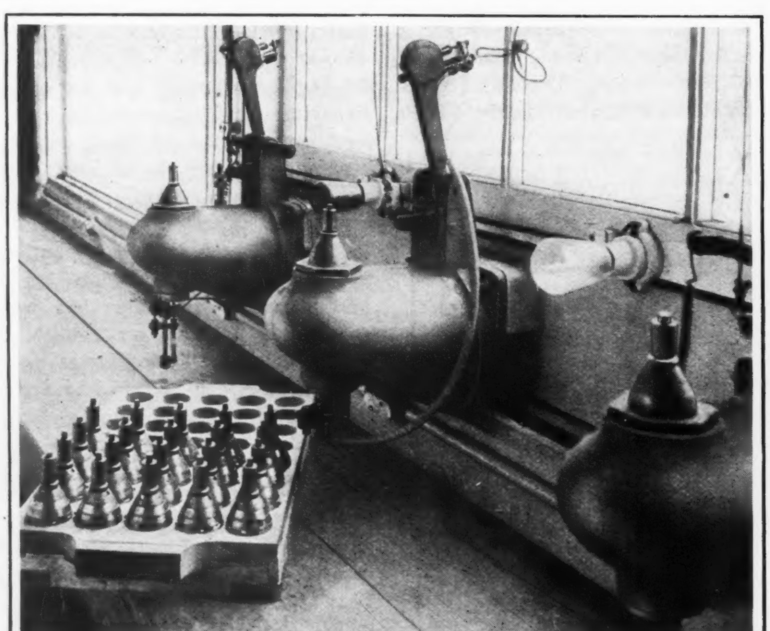


Fig. 8. Firing Heads used in Conjunction with Recording Machine illustrated in Fig. 7

The loading tool used in conjunction with this press is illustrated in Fig. 12. This tool is, in reality, a box which encloses the timing ring in order to prevent any distortion of the ring or unevenness in pressure on the powder train. Pressure is applied to the part *A*, which is shaped at the lower end to correspond to the groove or channel in the timing ring. The ring *H* to be loaded is pressed over a central plug *B* in an arbor press. This prevents distortion of the bore. The part *C* has a locating pin in it, which is shown at *D* in the detailed sectional view. This locating pin is the

means of guiding the sleeve *A* so that it does not shear the ends of the composition channel. The outer casing of the loading tool is held in place by a bayonet lock at *G*, which permits it to be removed quickly.

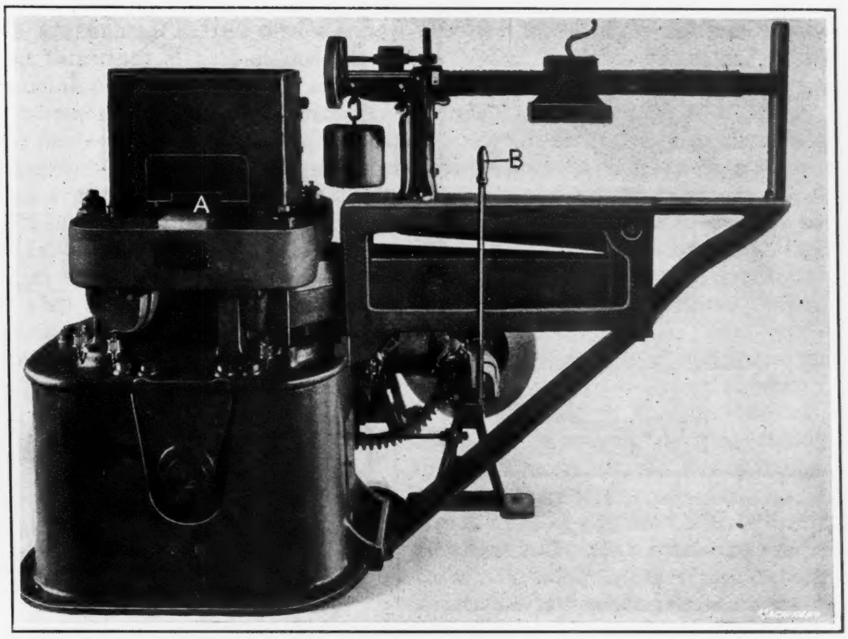


Fig. 9. Olsen Testing Machine adapted for applying Pressure to Powder Trains of Fuse Rings

After the rings are loaded, they are faced off, because the powder may be either slightly above or below the surface of the ring. Garvin or other suitable shaving machines are used for this work and the rings are held in place on pull-back collet chucks. These chucks (see Fig. 13) are so constructed that they are not easily broken, and they have eliminated considerable trouble wherever used. The ring is gripped by loose leaves or segments *B* that are held in place by drill-rod pins *A*. These segments are expanded for gripping the work by a central tapering plug which is drawn backward in the usual manner. These shaving machines revolve at 1000 revolutions per minute, giving a surface speed of approximately 600 feet per minute, which is not sufficient to ignite the powder. The chips of brass and the powder dust are drawn away by an exhaust pipe and conveyed to a water tank which "kills" the powder. If the powder is not properly pressed into the composition channel, or if the tool is not in good condition, the composition, when turned or shaved off, will have a pitted appearance, which is permissible if not excessive. It is interesting to note that stellite, when used as a cutting tool, will not generate a spark like high-carbon steel, and its cutting qualities are satisfactory.

After the facing operations, the rings are gaged. One type of gage that is used to test the concentricity of lip *R*, Fig. 2, with the bore of the ring is illustrated at *B* in Fig. 11. This is a double-ended gage having pilots which fit closely into the bore. The particular gage shown is for testing the bottom ring, which must enter one side of the gage, but not the other. The rings are next varnished by using a sable brush, 3/8 inch wide, and a mixture of orange shellac, methylated spirits, and a small percentage of Venice turpentine. This mixture should be evenly applied.

The burning time of the powder is perhaps the most bewildering part of fuse loading, because the test will show one result today and another that is quite contradictory tomorrow. It has been demonstrated, however, that careful attention to the various details involved in fuse loading is manifest later by the uniform and more satisfactory results obtained. A few points will illustrate the necessity of carefully watching the details. For instance, if the escape hole disks are fastened in very tight, or if the hole connecting the escape hole and the composition channel is not drilled, the burning will be very rapid, practically an explosion. If the flash hole in the top ring is drilled in the wrong location, the burning will also be affected. If the powder is broken away while drilling the vent hole, the results are likely to be erratic. The burning in the top rings is more uncertain than in the bottom ones.

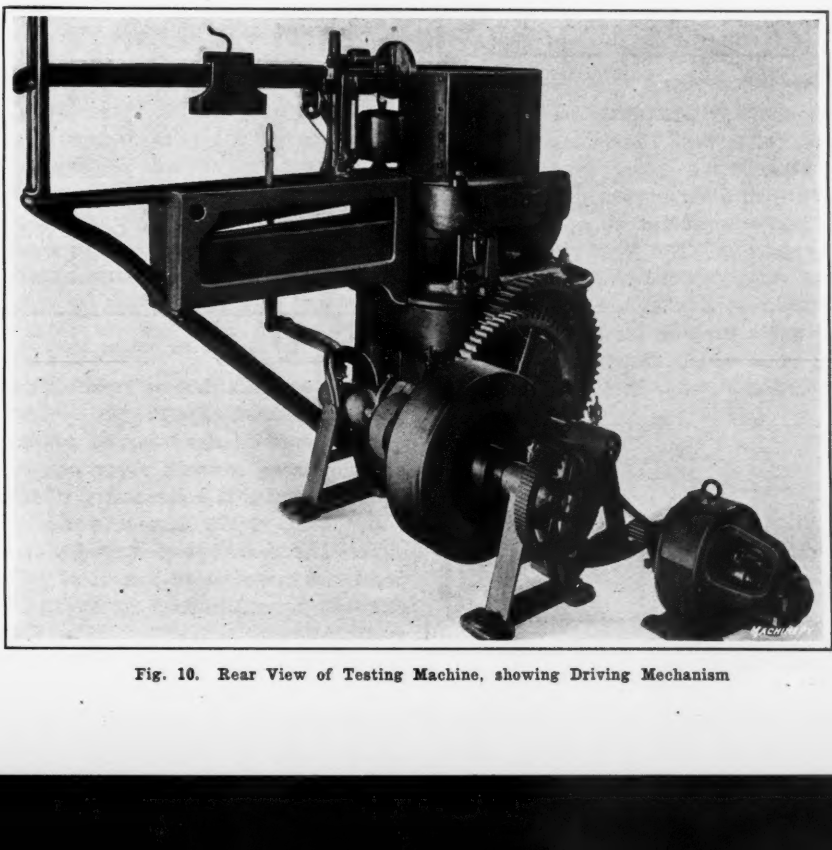


Fig. 10. Rear View of Testing Machine, showing Driving Mechanism

### Operations on Loaded Timing Rings

The assembling department which now receives the loaded rings is divided into sections, each of which is capable of turning out 10,000 rings in a nine-hour day. All the component fuse parts are conveyed and handled in lots of a hundred or multiples of a hundred, and the trays in which they are placed are standardized. This system simplifies the storekeeping. The sections of the assembling department are divided into top-ring, bottom-ring, and body benches. These benches are 4 feet wide and have a partition in the center. A 6-inch strip across the top of the partition forms a convenient shelf for holding trays, etc. The total length of each bench is about 36 feet.

The first operation is to ream the bore of each ring, which has been closed in slightly in the loading operation. A Henry & Wright drilling machine is used for this purpose; the fixture for holding the rings while reaming is shown at *A*, Fig. 14. The tapering seat in this fixture which receives the ring is semicircular, as shown by the plan view, and is open on the front side so that a ring can easily be inserted or removed. The ring is held downward by fingers *a* and *b*, which are connected to the fork-shaped handle *c*. This particular fixture is intended for the upper timing ring. The burr caused by facing the ring after pressing in the powder is next removed from the locating hole, after which a vent hole is drilled in the powder at the end of the composition channel. A rather unusual form of jig (shown at *B*) is used for this operation. This jig consists principally of a base *d* and the jig plate *e* to which the handle is attached. The ring to be drilled is held in place by plug *f* (which fits into the bore) and pin *g*, which enters the locating hole. After a ring has been placed on this combined handle and jig plate, the latter is pushed back into the V-shaped notch in plate

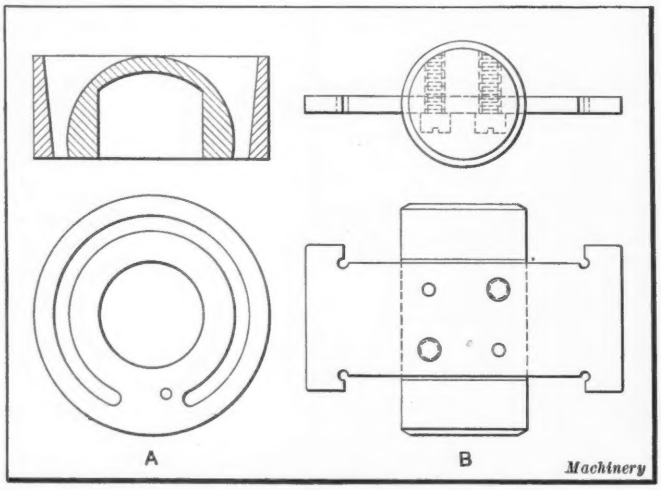



Fig. 11. (A) Special Funnel used for loading Fuse Rings. (B) Concentricity Gage for Fuse Rings

*h*, thus locating guide bushing *j* under the drill. This type of jig can be loaded and unloaded very rapidly.

The flash holes and the holes connecting the end of the composition channel with the escape hole are drilled in succession. The jig used for drilling the flash hole in the top ring is illustrated at *B* in Fig. 15. The method of testing the accuracy of the hole in the jig is illustrated by the detailed sketch *A*, Fig. 15. The end of a close-fitting rod or plug which projects through the jig hole should just make contact with a wire having a diameter of 0.0934 inch. The flash hole in the bottom

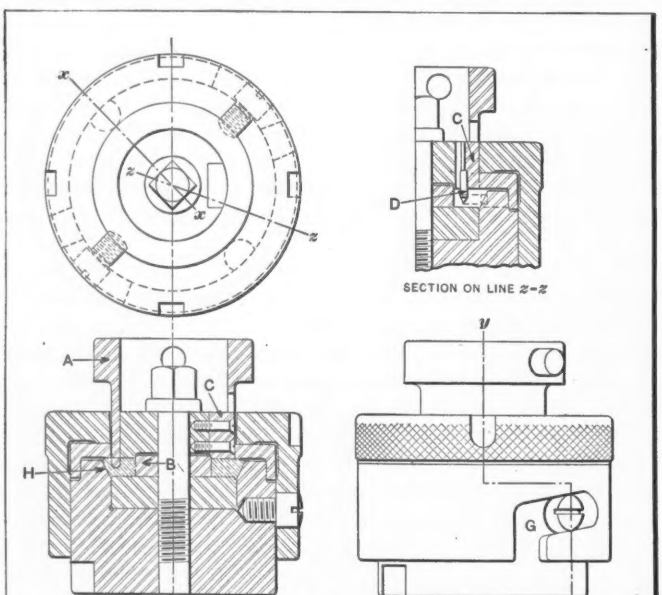



Fig. 12. Fuse Ring Loading Tool

ring is drilled on a double-spindle drilling machine. The counterbored part *K* (Fig. 2) is first formed. The wing *A*, Fig. 16, which carries the drill bushings is then swung back out of the way, and the small hole is drilled after moving the jig *B* along the base *C* to a position beneath the second spindle of the machine as determined by stop *D*. The jig for drilling the hole connecting the end of the composition channel and the escape hole is of the same general type as the one illustrated in Fig. 15, except that the guide bushing for the drill is in a projecting part of the jig body which extends out over the ring. The drill enters through the escape hole. The rings are

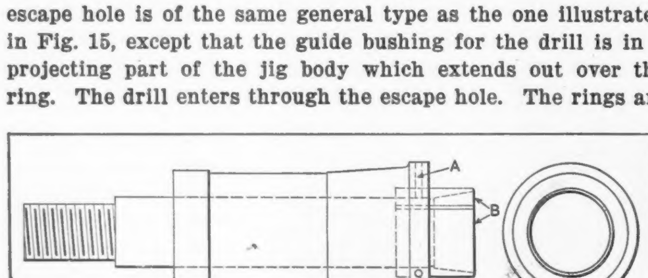



Fig. 13. Expansion Collet Chuck for holding Loaded Fuse Rings while facing

now gaged to test the accuracy of the drilling. The form of gage used for testing the diameter and depth of the flash hole in the bottom ring is illustrated in Fig. 17. The step at *A* indicates the maximum and minimum depths.

Powder pellets are next inserted in the escape holes, and the escape hole disks are put into place and "stabbed," which is accomplished by holding the ring at the correct angle and stabbing it with a die held in a Baird kick press. A small spring plunger holds the disk in place until the cutting face of the die strikes it. The shellac which is now applied to the ring acts as an adhesive for the paper washers which are put on before the shellac has time to dry. The faces of the rings should not be handled prior to this operation, because this will prevent the paper washers from sticking. These washers are applied to the lower faces of each timing ring,

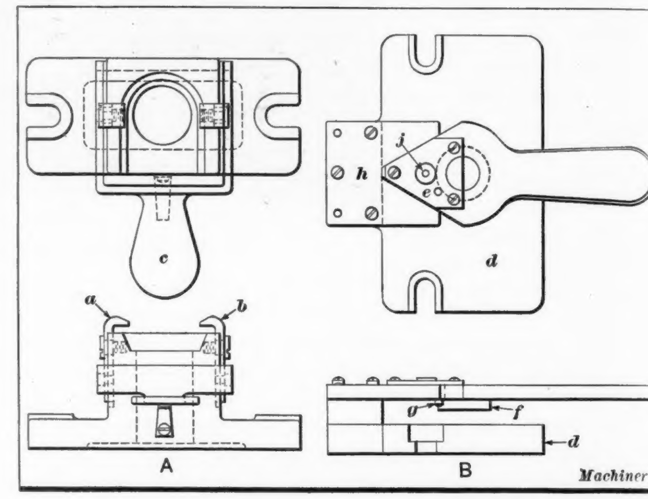



Fig. 14. (A) Fixture for holding Fuse Rings while reaming. (B) Jig for drilling Vent Hole in Powder at End of Composition Channel

and their purpose is to exclude moisture from the powder. The washer which adheres to a ring is smoothed out on a felt-covered board. After the shellac has been given a little time to dry, the top or serrated face of the lower timing ring is shellacked and a felt washer is placed over it. This washer is shown at *U* in Fig. 2, and, as will be seen, there is another washer between the lower timing ring and the fuse body. When these washers are placed in position it is important to see that the hole in the washer left for the flash exactly coincides with the hole in the timing ring or fuse body, as the case may be. The gage used for testing the position of the felt washer on the bottom timing ring is illustrated in Fig. 18. The flash hole is seen through hole *A* in the gage. This gage also checks the position of the flash hole and its

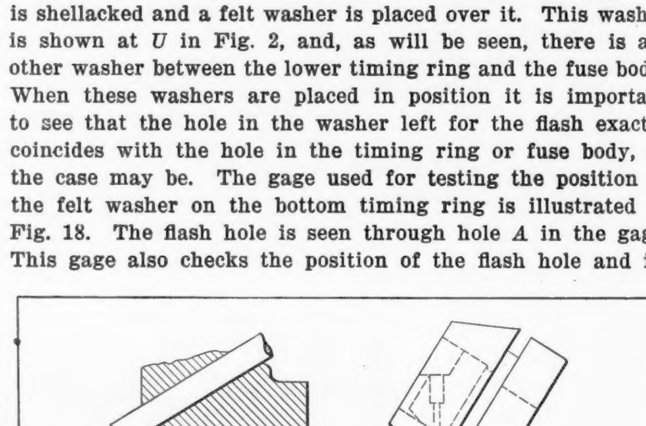



Fig. 15. Jig for drilling Flash Hole in Top Fuse Ring

relation to the index or lighting line, which should coincide with the beveled edge *B*.

A pressure of one hundred pounds is now applied to each ring by using a small arbor press. The application of this pressure makes it unnecessary to allow time for drying. The paper washers are waxed by lightly rubbing them over an electrically heated wax-covered plate, and the rough edges of paper are removed with a knife. The excess shellac is next removed from the flash holes, and either powder pellets or mealed powder is inserted. The insertion of mealed powder is a slower operation than inserting pellets, and consequently

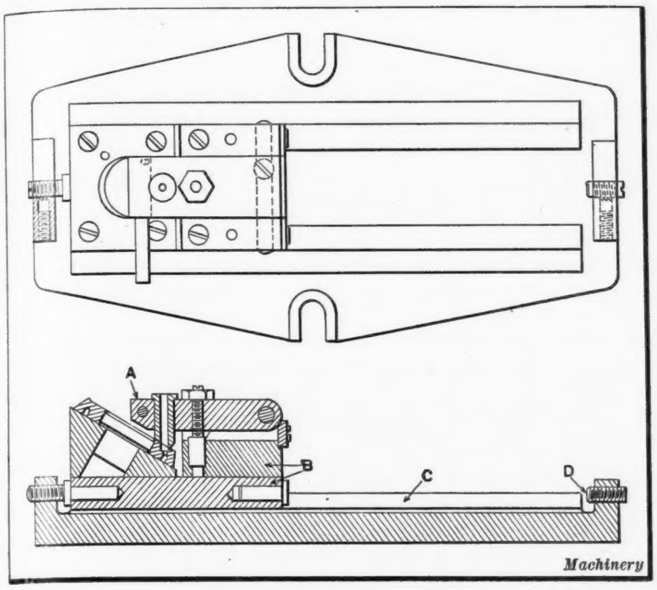



Fig. 16. Jig for drilling and counterboring Flash Hole in Bottom Ring

the former is not used much. Inspectors are located wherever necessary along the assembling benches, which eliminates any congestion, because if the work is not being done properly, it is stopped immediately.

### General Assembling Operations

The assembling operations on the body of the fuse are similar to those described for the bottom timing ring in so far as applying the felt washers is concerned. These washers, by the way, are kept in an electric heater until required, so that they will not absorb moisture. Some fuse manufacturers place the rings in an electric heater after lacquering them as a precaution against the absorption of moisture. After the felt washer is placed on the fuse body, the timing rings are set roughly in place and a drilling machine operator spots them accurately and drills the two securing pin-holes. The jig for drilling these pin-holes is illustrated in Fig. 19. The end of the spring plunger *A* engages the key slot in the body of the fuse, and pointer *B* is set on the index line, which is spotted by tapping the end of the pointer with a wooden mallet. The

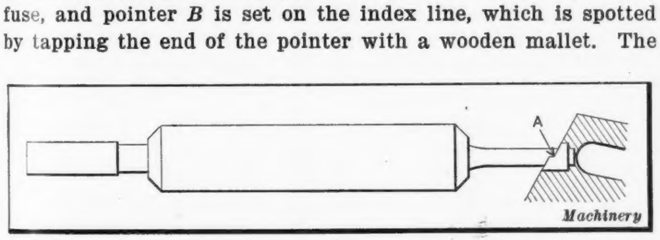



Fig. 17. Gage for testing Diameter and Depth of Flash Hole in Bottom Ring

top or jig plate *C* is next put into place and the holes are drilled. These holes are half in the stem of the fuse body and half in the upper timing ring. Pins are afterward inserted into them to serve as keys.

The drilling operation just described is not performed as quickly as the others, so that some of the work is conveyed to the opposite side of the bench by means of a mechanical conveyor and automatic distributor, which is illustrated diagrammatically in Fig. 20. This conveyor is equipped with a canvas belt which operates between wooden strips along the side, as shown. The fuse bodies are carried along by the belt in the direction indicated by the arrow. Some of the fuse bodies are required to go down the chute *D*, whereas others move straight along to the right-hand end of the conveyor. The path followed by the fuse body depends upon the position of the distributing arm which is pivoted at *E*. Whenever a body strikes the arm at *A* it moves straight along, but turns the distributor about pivot *E* so that the next fuse body comes into contact with arm *B* and slides down the chute *D*, thus striking arm *C*, which returns the distributor to its original position. After the rings have been removed and the burrs formed by the drilling operation have been filed off, the entire fuse is reassembled and the securing pin inserted.

### Screwing on Fuse Caps and Testing Friction of Timing Ring

The cap *B*, Fig. 2, is next put on and tightened down with the tensioning fixture illustrated in Fig. 21. The base *A* of this fixture, which holds the fuse body, is free to revolve when subjected to a load that will permit the bottom ring to be turned when the turning moment is equivalent to 144 inch-ounces within 12 inch-ounces plus or minus. When the cap is being screwed down to secure the right amount of friction for the timing ring, it is engaged by two pins *B* in the fixture, which enter small holes previously drilled in the cap. When the cap has been tightened sufficiently to lift the weight *C*, the fuse is removed from the fixture and allowed to stand over night.

The next operation is testing the tension or friction which is done by using the fixture illustrated in Fig. 22. This fixture is arranged to hold the base of the body stationary in holder *G* and revolve the lower timing ring. The ring is revolved twice to remove any high spots on the wax or felt washer before testing the tension. While the ring is being turned in this way, the catch *A* is in the position shown in the illustration. This catch is then released so that the spindle which holds the fuse is free to turn except as it is restrained by the weight *C* attached to the end of the arm or lever shown. The amount of friction or tension between the

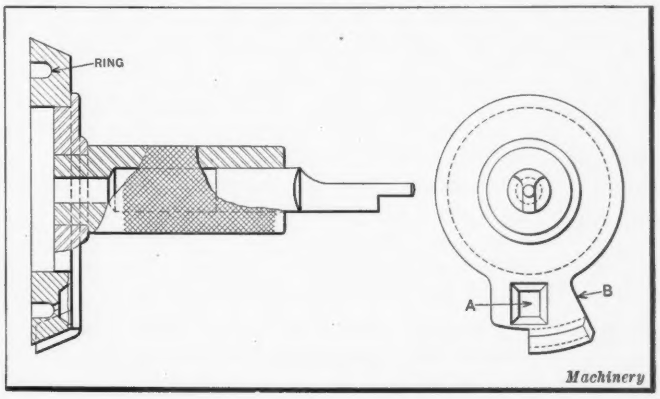



Fig. 18. Gage for testing Position of Felt Washer on Lower Timing Ring

ring and the fuse body is indicated by the height to which this weight is lifted, as determined by graduations on the housing of the fixture and a finger attached to the lever arm. The cup-shaped member *E* on the end of the crank spindle has projecting lugs *F* which engage a small pin on the lower timing ring. A small spring pin or clip *B* engages the U-slot in the body of the fuse and prevents it from turning relative to the holder *G* of the fixture. The cap-tightening or friction-setting fixture illustrated in Fig. 21 also has a similar pin for holding the fuse body against rotation. The bottom ring is now lined up to safety with the index mark on the top ring and the fuse is gaged to see that the top and bottom ring lines coincide with the left-hand side of the key slot. A simple form of gage is used for this purpose.

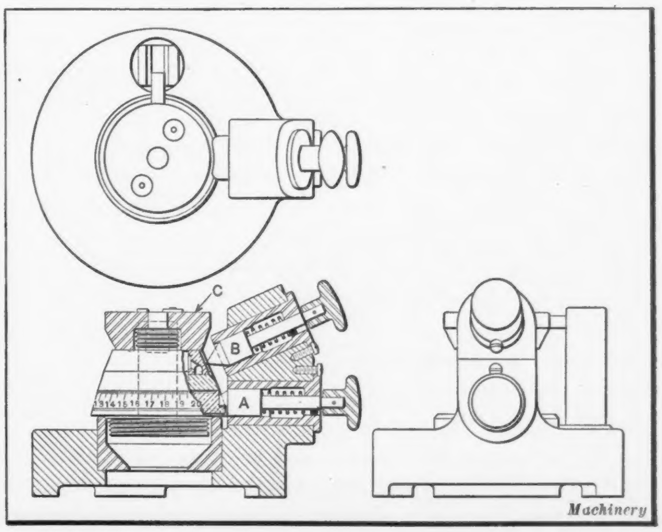



Fig. 19. Jig for drilling Holes in which Pins are inserted to hold Upper Fuse Ring in Position

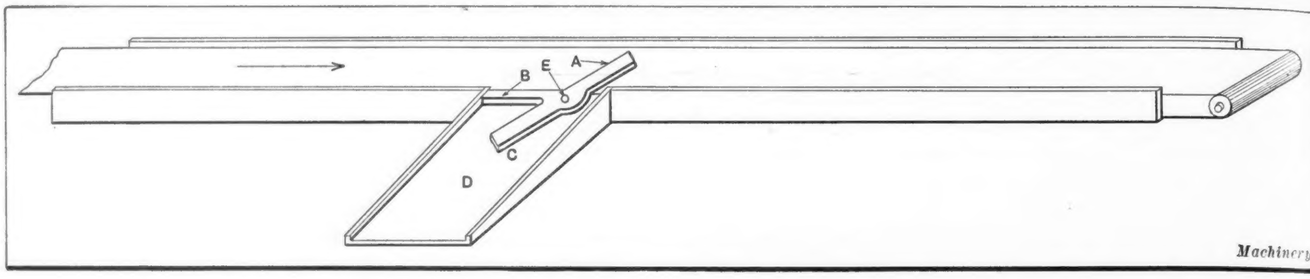



Fig. 20. Diagram illustrating Principle of Mechanical Conveyor and Automatic Distributor used in Fuse-loading Plant

One of the important points in connection with the tensioning test is to make sure that the stem or central part of the fuse body is at right angles to the platform or flange on which the timing ring rests and that the central stem is concentric with the projecting lip *R* (see Fig. 2). The concentricity gage, which is shown at *A*, Fig. 23, is a very simple form. This gage, which has "Go" and "Not go" ends, is simply inserted over the central stem of the fuse body; the latter is accurate as to size, and the gage enters the projecting lip of the body platform at one end, but will not enter at the other if the fuse body is properly made. This insures that the bottom ring will not catch. The gage for determining whether or not the stem is at right angles to the platform or flange is shown at *B*, Fig. 23. This gage is placed over the central stem of the fuse body, and the alignment between the lower ends of the gage and the flange of the fuse body is noted. This gage was used because the serrated surface in some cases was formed by a separate operation. If the tool used for this serrating operation were not properly set, or if this surface were not square with the central stem, the friction or tension of the adjustable ring would be uneven, and if the inaccuracy were considerable, the burning time of the powder train might be seriously affected by an excess amount of air entering between the felt washer and the ring face.

### Putting in Base Charge

The hole for set-screw *S*, Fig. 2, which holds the cap in position, is next drilled and the screw inserted. The percussion pellet *N* and the other parts connected with it are now inserted, after which the base plug *T* is screwed into place. The base charge is then put into the fuse through the filling hole. This is done by placing a convenient number of fuses in a suitable frame, which is carried by a cradle over which are suspended the same number of funnels as there are fuses to be filled. These funnels contain the correct amount of powder which is deposited in the fuses when the cradle is jolted by a cam which lifts it and allows it to fall, striking the bench. Some concerns use pneumatic vibrators for this work, but these are very noisy as well as costly. The funnels may conveniently be filled with powder by having a horizontal tube with a rotary lining, which, as it revolves, permits the powder to fall through holes into the hopper beneath. After the filling-hole screws are driven into place, a waterproofing material is rubbed into the junctions of the ring, cap, and body. This material is composed of the following parts by weight: beeswax, 2 parts; mineral jelly, 1 part; French chalk, 2½ parts. This composition is put on with a flat stick, while the fuse is rotated with the hand fixture illustrated at *A* in Fig. 24. The end of the spindle of this fixture has a hole which is threaded to suit the fuse body. Any excess composition is removed with a rag.

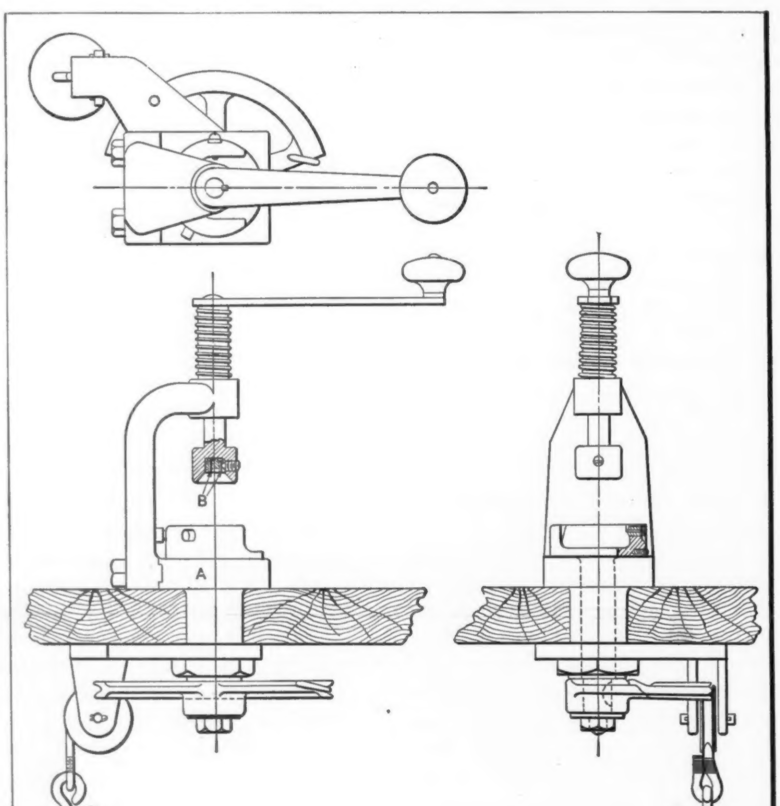



Fig. 21. Device used for screwing on Fuse Caps, which is arranged to regulate Friction or Tension

### Testing Weather Covers

The next operation is that of soldering the weather covers in place. These covers must be air-tight, and they are tested previously by using a special vacuum testing apparatus having a barometer tube which connects three valves to a block that carries a rubber washer. The cover to be tested is placed on this washer and is connected to the vacuum chamber. The gage glass is first connected to the vacuum chamber, which causes the mercury column to rise, the cover at this time being disconnected from the vacuum. The vacuum chamber is next disconnected from the tube and the cover is connected with the vacuum. If the cover is tightly jointed, the column of mercury will fall to a definite level and remain there, whereas any leaks will be indicated by the fact that the mercury continues to fall. As some time elapses before the column of mercury comes to rest, it has been found that if ten covers and ten tubes are used, by the time the last cover is placed in position the first mercury column will be ready for reading.

### Minor Operations on Fuses

There are a few minor operations which a loading plant generally performs on the body and smaller parts which make up the fuse. One of these operations is assembling the time and percussion pellets *E* and *N*, Fig. 2; this includes inserting the detonator and the screw plug which holds the detonator in position. The hand fixture *B*, Fig. 24, is used for screwing these plugs into place. The pellet is held in the split clamp *a*, which is opened or closed by a screw connecting with hand-lever *b*. The spindle carrying the screw-driver *c* is pressed down

by hand when inserting a screw and then is automatically withdrawn by the spring shown. These screws are fastened into place by a "stabbing" operation, which is done in an ordinary kicker press having a dial feed. The lot numbers and dates are also stamped on the bases of the fuse bodies in a kicker press which has the foot-lever removed, the ram being lifted by hand and allowed to drop freely. A blow was found necessary in order to stamp the figure properly. An operator is capable of stamping 6000 fuse bodies in nine hours by this method.

The felt washers *U* and *V* (see Fig. 2) are cut out on a punch press equipped with an automatic roll feed having only one roll at the pushing end and two rolls at the pulling end. The felt is supported on vulcanite while being cut. One press cuts 30,000 washers per day of nine hours. As the washers and blanks are not separated completely from the felt stock on account of small threads which hold them, the felt is passed over an arm attached to the housing of the press. This arm has a projection on it which is jolted by the descending press ram striking it, and this serves to shake the blanks free from the stock. The linen washers are punched from four thicknesses of stock with a gang punch, which cuts over 200,-000 in nine hours. These washers are punched through a

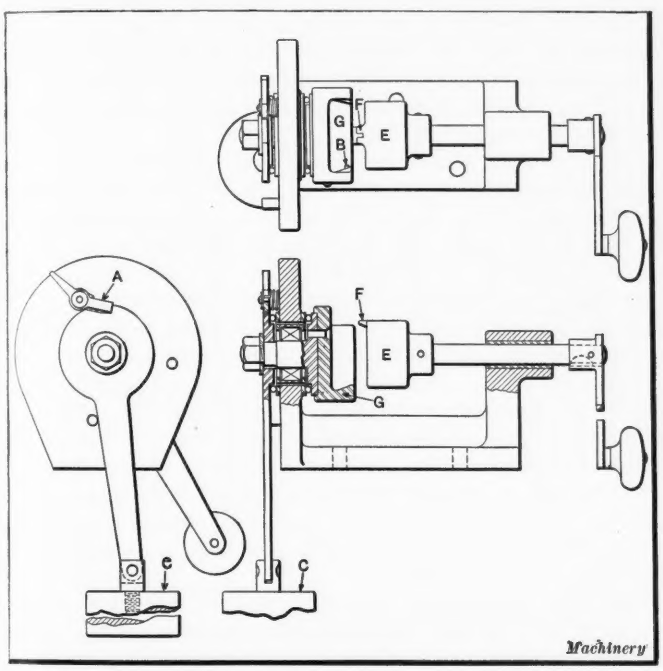



Fig. 22. Apparatus for testing Tension or Friction of Adjustable Timing Ring

hard die by punches which were left soft so that they were trimmed or shaved to the proper shape by the die.

The lead washers which are inserted under the needle *G*, Fig. 2, caused trouble at one time, owing to the metal clinging

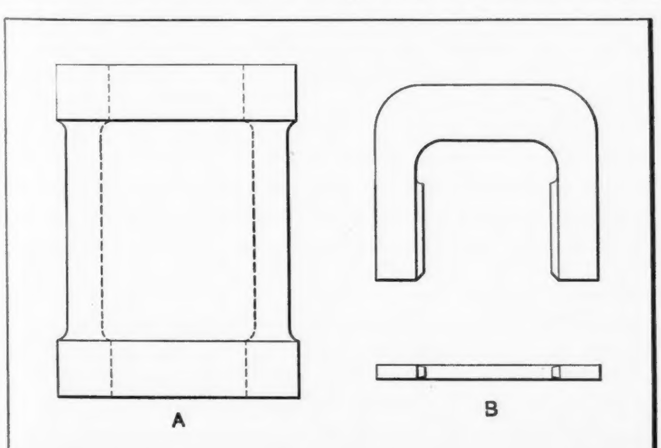



Fig. 23. (A) Gage for testing Concentricity and Diameter of Fuse Body Platform or Flange. (B) Right-angle Gage for testing Position of Flange Relative to Central Stem of Fuse Body

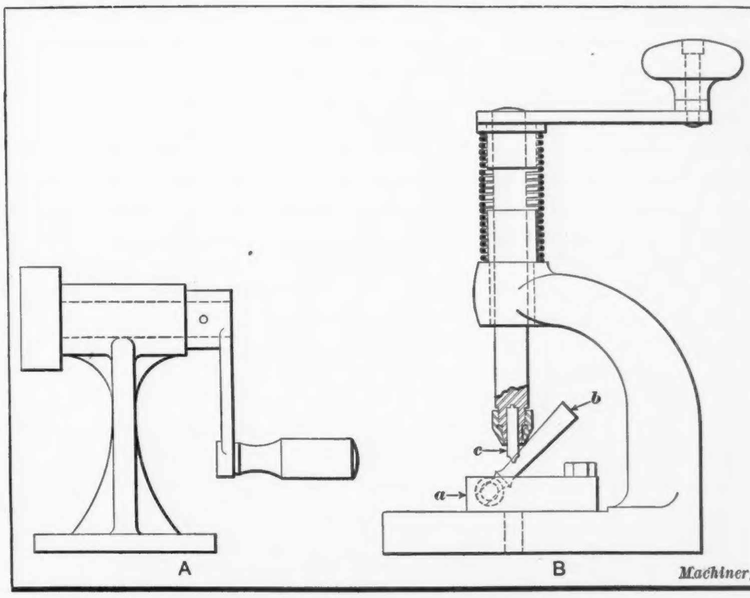



Fig. 24. (A) Fixture for rotating Fuse while applying Waterproofing Composition. (B) Hand-operated Fixture for inserting Screw Plugs that hold Detonators in Time and Percussion Pellets

to the clearances of the die. A small percentage of antimony and tin was added with satisfactory results. These washers are first drawn to a cup shape, so that when they are afterward flattened out beneath the flange of the needle or firing pin, the recess beneath this flange will be completely filled, thus forming a tight joint. If there is any escape of the time pellet explosion past this washer, a premature explosion will occur, often with serious results.

The rate at which these small parts are assembled is indicated by the following figures representing one girl's production in nine hours for each of the respective operations: 600 needles inserted in the fuse body; 800 ferrules painted with shellac; 5800 detonators put in the percussion pellet; 5800 detonators put in the time pellet; 5800 disks put in the detonators; 5800 screws driven in the pellets; and 12,000 pellets stabbed.

The making of the powder pellets for the flash and escape holes is performed in an isolated department. Formerly power presses equipped with accumulators were used, but the opera-

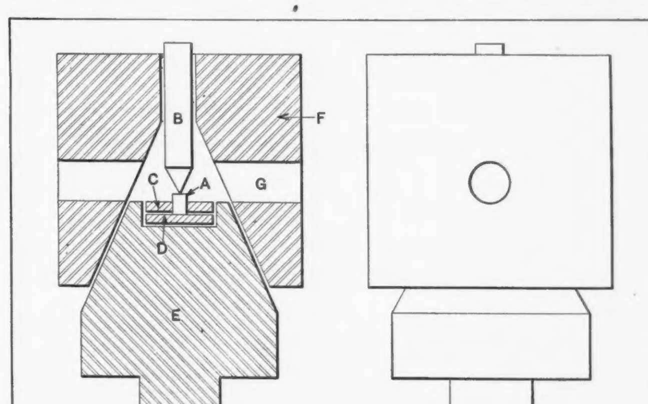



Fig. 25. Part of Detonator Testing Apparatus

tion was slow, only 16,000 pellets being produced in nine hours by three machines. Hess & Barker pill-making machines are now used for this work, and one machine produces 6000 powder pellets per hour. These machines are automatic in their operation.

### Testing Completed Fuses

The fuses which are selected for the proof test are treated as follows: The percussion mechanism is removed from ten fuses, which are then fired in the electrical testing machine to determine the mean or average time of burning when the fuse is at rest. When the time fuse is set for the greatest length of time, the mean time of burning, when corrected for the barometer, should be 22 seconds plus or minus 0.2 second.

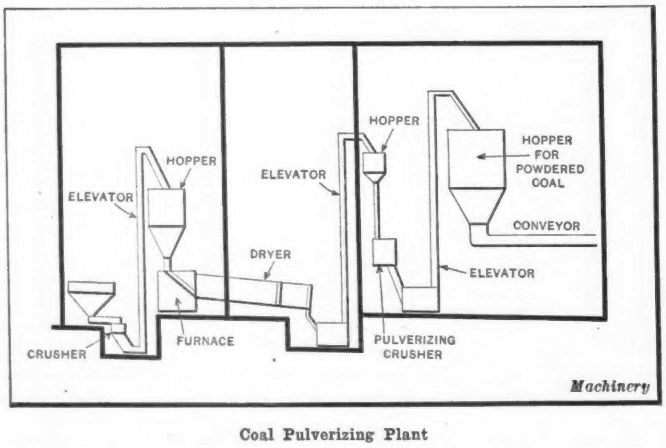
The constant used when correcting for the barometer is at the rate of 0.023 of the mean time of burning for every inch the barometer is above or below 30 inches. This value is added when the barometer is above 30 inches and subtracted when it is below that point. The burning time of each fuse is tested while the fuse is revolving at 2500 revolutions per minute, and the time must be within the limits specified. The fuses are also subjected to time and percussion tests by attaching them to shells and firing from a gun. The detonators are tested by a falling weight, and if they fail to explode, the entire lot is rejected. A part of the detonator testing apparatus is illustrated in Fig. 25. The detonator is in contact with a steel needle *B*, upon which the weight falls. The detonator is surrounded by a strawboard washer *C* about 1/8 inch thick and a copper disk *D* about 1/16 inch thick. The base *E* and the part *F* which encloses the pin and detonator are made of steel. A hole *G* is drilled through part *F*, so that the one making the test can see whether or not the needle is resting properly on the detonator. The weight which strikes the needle is held up by an electric magnet, which allows the weight to fall when the current is shut off. The falling part weighs three or four ounces and drops from heights varying from six to ten inches, depending upon the kind of detonator tested. These detonators are made from a mixture of chlorate of potash, sulphide of antimony, and fulminate of mercury. They are highly explosive when scratched or rubbed even very slightly, and for this reason the precaution is taken to have the benches on which the detonators are handled divided from the adjacent ones by glass partitions to guard against flying particles of copper.

* * *

## SOLUTION OF THE FUEL PROBLEM

BY G. C. W.

Now, when the conservation of our natural resources is necessary and when transportation facilities are uncertain, the fuel problem is becoming more difficult to solve; but is it the shortage of coal that is troubling us as much as the question whether we are using what we do receive to the best advantage? Ordinarily, large users specify the number of British thermal units, the quantity of ash, moisture, etc., that the coal shall contain, but existing conditions do not permit this to be done. It might, however, be possible to make a change in the quality of the coal or to rearrange the furnace or apparatus, paying particular attention to the personal factor, and make complete tests. The analysis of the coal, the kind




Coal Pulverizing Plant

of grate and draft, size of coal, etc., are also contributing factors.

A great deal of thought is being given to the burning of dust, sweepings, culm, slack, screenings, strip-pit products, as well as lignite, peat, and the larger sizes of coal when dried, pulverized, and burned in suspension. Burning in suspension develops every contained heat unit just where it is wanted and not up the stack, etc. An accurate control of the air blast, which is not dependent on the condition of the atmosphere, grates, fuel bed, or wind velocity, supplies only the air necessary for complete combustion and the whole heat of the fuel is available at once. The air pressure should be 1 ounce at the nozzle and 4 to 6 ounces in the coal feed. Preheating the air to 500 degrees F. saves 20 per cent of the fuel. This preheating is easily accomplished by passing a few lengths of blast-supply pipe through a chamber heated by the waste gases.

Coal containing as little as 28 per cent volatile combustible matter, 11 per cent ash, and 2.7 per cent sulphur is being burned successfully, except in cases where it is important that the composition of the material being worked is not affected by the sulphur. The moisture content should be below 1 per cent and preferably below 0.5 per cent. As powdered coal absorbs moisture at the rate of 0.01 per cent per minute for 50 minutes, when the rate decreases, care must be taken to keep it covered. The drier the coal, the easier will it grind and

COST OF OPERATING AVERAGE PULVERIZING PLANT

| Capacity of Plant, Short Tons per Hour | Cost per Ton, Cents | Capacity of Plant, Short Tons per Hour | Cost per Ton, Cents |
|---|---|---|---|
| 2 | 35 to 60 | 10 | 22 to 40 |
| 4 | 30 to 55 | 25 | 20 to 30 |
| 5 | 24 to 45 | .. | ........ |

*Machinery*

the easier can it be handled, for it will not then tend to form lumps and clog the conveyors. This moisture is not so much that produced by ice, snow, rain, etc., but it is, rather, the inherent moisture of the coal, and in drying coal the more moisture it contains the more expensive will be the drying operation. When the moisture in the coal exceeds 10 per cent, it cannot be reduced to 0.5 per cent by drying.

It is important that 95 per cent of the pulverized coal should pass through a 100-mesh sieve and 80 per cent should pass through a 200-mesh sieve. The feed-controlling element and the size of the burner are important and should be varied according to the size of the furnace.

In the pulverizing plant shown in the accompanying illustration, the cars of fuel are run upon a siding at one end of the milling building and empty the coal into a concrete pit beneath the tracks. This pit contains a hopper, 8 feet square and 6 feet deep, made of 3/8-inch steel plates that feeds into a standard 6-inch U-shape cable conveyor that has adjustable cast-iron supports. This conveyor takes the coal to a crusher, which is able to break 8-inch lumps into 3/4-inch cubes; these are then fed into the pulverizer. Crushers are sometimes provided with means for allowing foreign substance to go through without breaking the machine.

From the crusher, the coal is elevated 35 feet by a bucket conveyor to a 60-ton bin, which has a hopper bottom, from which it is fed to the dryer by a 12-inch standard screw conveyor. This dryer is composed of two concentric shells made of heavy steel plates; the inner shell, or flue, is connected with the ouside cylinder at the center by six heavy cast-iron arms riveted at both ends. The shell is 48 inches in diameter and 20 feet long. It is supported by rollers and is revolved by spur gearing at a speed of six revolutions per minute. The flue is connected with a furnace and the hot air passes through to the space between the inner and outer shells. A belt-driven, centrifugal, exhaust fan connected to the dryer removes the spent gases from the shell and discharges them through a centrifugal dust collector, which gathers all the fine particles of coal dust taken up in passing through the dryer. An elevator now carries the coal to a dry-coal bin, from which it passes to the pulverizing mill. The coal is then stored in the powdered-coal bin. The dryers and pulverizers should be located in separate buildings on account of the liability of explosions.

A general average of the cost of operating pulverizing plants is given in the accompanying table. The initial outlay is not so great if one is familiar with what is required, as all the appliances are rough work, consisting of boiler plate, piping, etc. The location of the plant in relation to the source of supply is of the utmost importance when considering the installing of a pulverizing plant, as on it depends the amount of saving that will be effected.

## TWISTING AND BENDING MOMENTS IN SQUARE AND RECTANGULAR BARS[1]

BY VICTOR M. SUMMA[2]

The section modulus for square bars is $Z = \dfrac{a^3}{6}$, in which $a$ is the length of the sides, and the polar section modulus is $Z_p = 2/9\,a^3$. Calling $M$ and $T$ the bending and twisting moments, respectively, the stresses are:

$$S = \frac{6M}{a^3}, \text{ and } S_s = \frac{9T}{2a^3} \qquad (a)$$

The values are then substituted in

$$P_1 = 1/2\,(S + \sqrt{S^2 + 4S_s^2}) \text{ and } P_2 = 1/2\,\sqrt{S^2 + 4S_s^2}$$

(which are given in "Combined Twisting and Bending Moments," December, 1917) in which:

$S$ = unit stress in tension or compression;
$S_s$ = unit stress in shear;
$P_1$ = greatest unit stress in tension or compression produced by the simultaneous stresses $S$ and $S_s$;
$P_2$ = greatest unit stress in shear produced by the simultaneous stresses $S$ and $S_s$.

The results are:

$$P_1 = 1/2\left(\frac{6M}{a^3} + \sqrt{\frac{36M^2}{a^6} + \frac{4 \times 81 \times T^2}{4a^6}}\right)$$
$$= 1/2\left(\frac{6M}{a^3} + \frac{1}{a^3}\sqrt{36M^2 + 81 \times T^2}\right)$$
$$= 1/2\left(\frac{6M}{a^3} + \frac{6}{a^3}\sqrt{M^2 + 2.25T^2}\right)$$
$$= \frac{3}{a^3}\,(M + \sqrt{M^2 + 2.25T^2})$$
$$= \frac{M + \sqrt{M^2 + 2.25T^2}}{\dfrac{a^3}{3}}$$

Divide the terms of the above fraction first by 2 and then by 9/2; the results are:

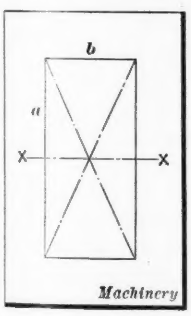



Diagram for obtaining Section Moduli of Rectangular Bars

$$P_1 = \frac{1/2M + 1/2\,\sqrt{M^2 + 2.25T^2}}{\dfrac{a^3}{6}}$$
$$= \frac{1/2M + 1/2\,\sqrt{M^2 + 2.25T^2}}{Z} \qquad (1)$$
$$P_1 = \frac{2/9M + 2/9\,\sqrt{M^2 + 2.25T^2}}{2/9 \times \dfrac{a^3}{3}}$$
$$= \frac{2/3M + 2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p} \qquad (2)$$

Since $P_2$ is nothing else than $P_1$ minus the term outside the radical:

$$P_2 = \frac{1/2\,\sqrt{M^2 + 2.25T^2}}{Z} = \frac{2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p} \qquad (3)$$

For rectangular sections $Z = \dfrac{ba^2}{6}$ or $\dfrac{ab^2}{6}$ and $Z_p = 2/9\,ba^2$ or $2/9\,ab^2$, according to the fibers being investigated along side $a$ or side $b$ as illustrated. Under flexure about axis X–X, the portion of the material that is most strained is along side $b$, and the moduli to be used are $Z = \dfrac{ba^2}{6}$ and $Z_p = 2/9\,ba^2$. Substituting as in Formulas $(a)$:

$$S = \frac{6M}{ba^2} \text{ and } S_s = \frac{9T}{2ba^2}$$

By comparing these values with Formulas $(a)$ it will be noticed that the only difference is in the denominators. Therefore, substitute $ba^2$ for $a^3$ in Formulas (1), (2), and (3) and the following equations result:

$$P_1 = \frac{1/2M + 1/2\,\sqrt{M^2 + 2.25T^2}}{\dfrac{ba^2}{6}} = \frac{1/2M + 1/2\,\sqrt{M^2 + 2.25T^2}}{Z}$$
$$P_1 = \frac{2/9M + 2/9\,\sqrt{M^2 + 2.25T^2}}{2/9 \times \dfrac{ba^2}{3}} = \frac{2/3M + 2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p}$$
$$P_2 = \frac{1/2\,\sqrt{M^2 + 2.25T^2}}{Z} = \frac{2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p}$$

Remembering the distinction between either $Z$ or $Z_p$ for square and rectangular sections, the following formulas give the maximum stresses of both:

$$P_1 = \frac{1/2M + 1/2\,\sqrt{M^2 + 2.25T^2}}{Z} = \frac{2/3M + 2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p}$$
$$P_2 = \frac{1/2\,\sqrt{M^2 + 2.25T^2}}{Z} = \frac{2/3\,\sqrt{M^2 + 2.25T^2}}{Z_p}$$

The user of these formulas should not forget their derivation, not only with reference to the cross-section of the bar under investigation, but also to the two expressions of section moduli of non-circular members.

* * *

## TIME EFFECT IN REHEATING STEEL

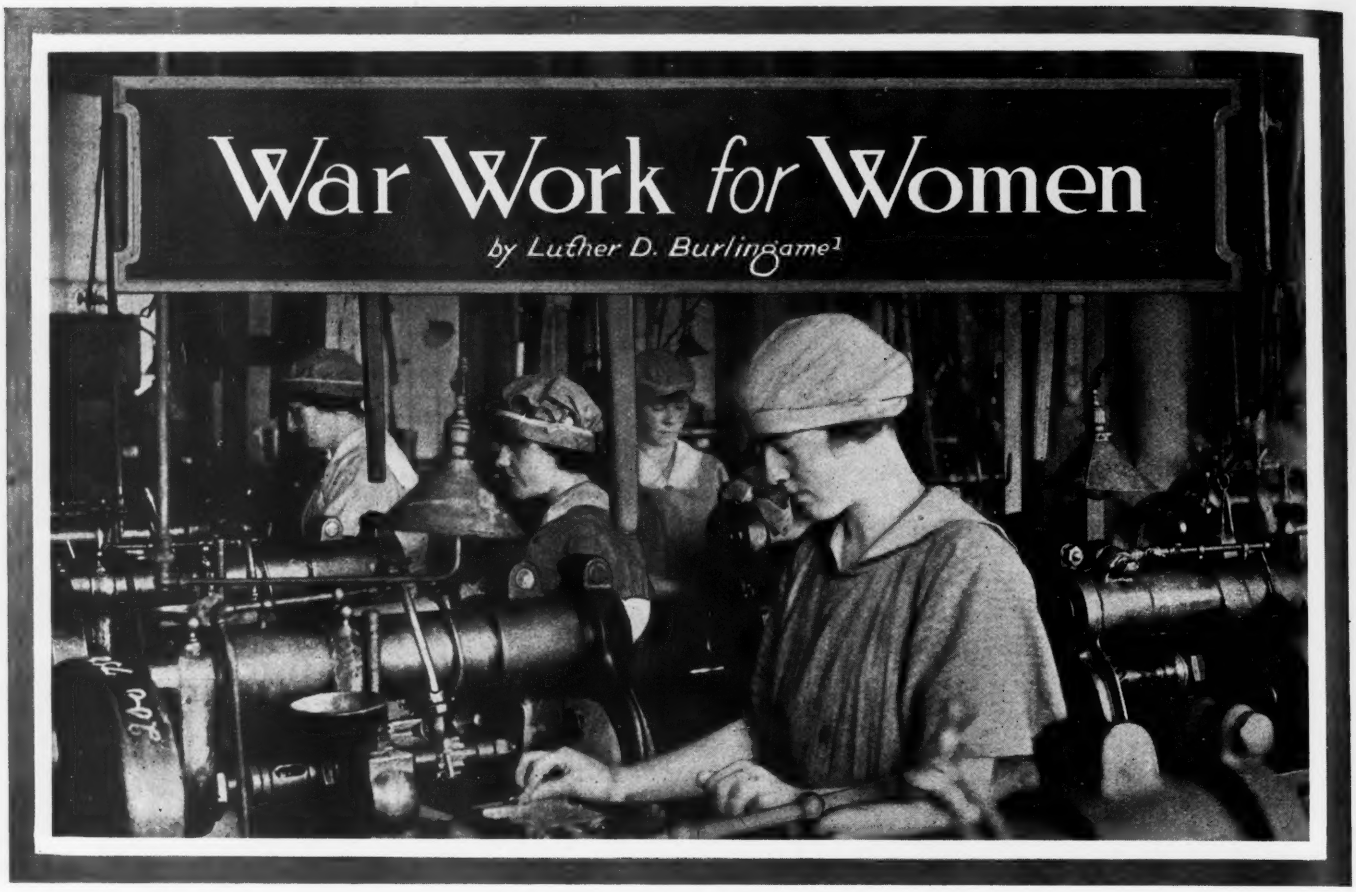
According to a paper read before the American Institute of Mining Engineers by A. E. Pellis, metallurgist of the Springfield Armory, the time effect in reheating certain steels below the critical range is very marked. Increasing the drawing time increases the machineability, ductility, and resilience; though the elastic limit and tensile strength are lowered, this loss is slight compared to the relatively great increase in ductility and impact strength. It was found that at least a two-hour reheating is necessary to produce satisfactory machineability in a steel containing 0.54 per cent carbon, 0.05 per cent sulphur, 1.22 per cent manganese, and 0.065 per cent phosphorus. Untreated, this steel has an elastic limit of 69,800 pounds per square inch, a tensile strength of 128,700 pounds per square inch, an elongation of 15 per cent, and a reduction of area of 35.2 per cent. At the end of one hour's reheating the steel has an elastic limit of 124,250 pounds per square inch, a tensile strength of 137,000 pounds per square inch, an elongation of 17 per cent, and a reduction of area of 42.2 per cent. Twelve hour's reheating decreases the elastic limit to 98,750 pounds per square inch and the tensile strength to 116,500 pounds per square inch, and increases the elongation to 22 per cent and the reduction of area to 57.2 per cent.

* * *

## LOST TIME THROUGH ACCIDENTS

A report recently issued by the United States Bureau of Labor Statistics on accidents in the machine building industry indicates that, in spite of all that has been done to prevent accidents, there are still too many industrial casualties. The bureau investigated 194 plants and found that on an average each worker lost 5.6 working days out of 300 in a year, due to accidents. Yard labor shows the highest percentage, with 29 days lost per worker due to accidents in a year. Boiler shops also show a high rate of lost time due to accidents, primarily as the result of insecure trestles and scaffolding. The high rate of accidents in yards is due to general neglect of safe location and construction of transportation systems, coupled with a lack of safety precautions and instructions. Accidents from falling objects are more frequent, apparently, than any other, the annual rate being fourteen per one thousand workers. Cranes and hoists appear to cause the most serious accidents, if the average time lost through accidents due to this cause is considered as a measure of the severity of the injury.

[1] See also MACHINERY, August, 1914, "Compound Stresses"; March, 1916, "Formulas for Combined Bending and Torsional Stresses"; and December, 1917, "Combined Twisting and Bending Moments."
[2] Examining Engineer, American Brake Co., St. Louis, Mo.




AT the time when the industrial inventory was taken by the Naval Consulting Board in order to ascertain the resources of the nation for war purposes, a question which was put squarely up to each manufacturer was: "To what extent can women be employed in your factory to replace men?" This brought widely varying answers. On the part of those who had informed themselves as to the extent to which women were being successfully employed in England and on the continent, the answer to this question was very different from what it would have been a year or two earlier, before the success of women in such work had been demonstrated. Even these employers, however, had little realization of how quickly and effectively women's work would be able to fill the gaps made in the working forces in our machine shops. The estimates made at the time of taking the industrial inventory as to the extent to which women can be used are now being put to the test, and it is being learned that women, under proper supervision and training, can quickly fit not only into the lines of work which it had previously been thought they were adapted for, but also into many lines which it had been felt could be performed only by trained mechanics.

The consideration given by the officials of the Brown & Sharpe Mfg. Co. to the matter of the employment of women at the time of filling out the inventory referred to had paved the way, so that as soon as America entered the war, steps were taken to make use of women's services in the machine shop. Up to that time no women had been employed by the company for machine shop operations or for any work connected with the machine shop, the employes holding clerical positions throughout the shop, as well as tool-room attendants, and those employed in the packing and shipping departments having been men. At the present time about 750 women are employed in shop positions. The first step toward the employment of this class of help was to prepare locker and rest rooms at accessible points throughout the factory, with suitable provision for their convenience, a serious problem being to find space when every available inch was required for production. These accommodations were finally arranged for with comparatively little curtailment of manufacturing space, one of the largest of these rooms being located on the roof of a one-story building, reached by a covered passageway.

[1] Industrial Superintendent, Brown & Sharpe Mfg. Co., Providence, R. I.

It is estimated that in order to provide satisfactory accommodations of this kind for women employes the average cost is about $25 and the space required about ten square feet per employe. Figs. 3, 4, and 5 show the furnishings and the equipment provided. A gas stove is placed in each rest room, as shown in Fig. 5.

It was felt, in order to secure and retain the services of the class of girls desired, not only that the legal provisions as to such accommodations for employing women should be met, but also that the condition of the factory should be maintained at a specially high standard as to cleanliness, orderliness, safety, and discipline. The success of efforts in this direction was indicated by a remark of one of the girls who stood talking with her foreman. Picking up a key she had accidentally dropped, she said, "I must not lose that; it is my key to heaven." The foreman asked her what she meant by calling that her "key to heaven," and she said: "It is my locker key. Having a locker all to myself is so much better than any provision I have had in any other place where I have worked that I call it my key to heaven."

From our experience in the employment of women, we believe that by starting in on a small scale, beginning in departments where the work is most directly adapted to their employment, and gradually extending the work to new departments, much better results can be obtained than by waiting until the emergency is so great that, in order to carry on the work at all, large numbers must be hired during a short period, without allowing time for the individual attention needed.

The method pursued by the company for introducing the employment of women into their machine departments was to first set aside one corner of a room for training. Six girls were employed and each taught a different operation, selecting, first, operations which seemed most suitable for such employes. When they had become sufficiently proficient so that their production was on a commercial basis, they were transferred to the departments of the shop where such work as they had been taught was being done and occupied places among the regular workers. Within a few days a second girl was put beside each of these, and this gave not only a sense of companionship but served as a stimulus to both girls; to the first to set the pace, and to the second to keep up or excel. The ice thus being broken, additional girls were added as rap-

Fig. 1. Automatic Gear-cutter Work in which Girls are taught to set up and measure

Fig. 2. Sharpening Cutters on Tool Grinding Machines, showing Exhaust System for carrying off Dust, and Comfortable Chairs for Girl Operators

idly as they could be assimilated, and their employment has since spread to all parts of the shop, so that now there are few departments, except the foundry, that do not employ women.

### Comparison between Men and Women Workers

In our own experience, without doubt, much more attention has been given by foremen and fellow-workmen to the supervision of women's work than has been given to the average male employe in the past, the assumption being that a woman, having less mechanical background and intuition than a man, required more training and more specific instructions. This has been the reason advanced by some foremen in explaining why women were doing better work and had "broken in" more quickly than men, and they have added, "If we had given the same kind of attention to each new man employed, he would have done just as well as the girl"; this is, after all, an admission on the part of the foreman that he had not in the past helped all he could, and an indirect compliment to the girl having much significance. It may be noted, however, that at the time when such comparisons were made, the average man who could be secured was of an unsatisfactory and irresponsible class, as so few trained or competent men were available for positions in the industries, while, on the other hand, in hiring girls, a selection from a large number of applicants could be made, so that it was possible to obtain a much better average having the qualities to make successful workers.

Many of the theories which some officials and foremen had held regarding the troubles and problems which would arise in the employment of women have been exploded when put to the actual test. For example, it was believed by some that the best results would not be obtained by having men and women work together in the various departments, but that there should be separate departments for each. Experience has shown that there are advantages in having both in the same department, as it tends to hold the same standard of workmanship and speed for women as for men, while it is believed that having a separate department for women may establish a separate and lower standard, the tendency being to make more allowance for women because of sex. The results seem to show that it is not at all necessary that separate standards should be established and that in some lines of work even more can be expected of women than of men because of their nimble fingers and quickness of motion. As to questions of discipline, where the two sexes are employed in the same workroom, little or no difficulty is experienced under capable foremanship.

Actual results have proved that the fears in the minds of some that there would be opposition on the part of foremen and workmen to the employment of women in the shop were ungrounded. A foreman remarked to a visitor: "See that girl working beside the man assembling speed indicators. She is working with him so as to learn all the requirements, and he knows that she is to have his job as soon as she has become sufficiently proficient, but he is helping her in every way possible. Of course, we shall find other work for the man; and often, with the present shortage of help, such a change of work can be in the line of promotion." This illustrates the spirit which is practically universal throughout the shop, and which has been an important factor in bringing about the success of the plan.

While the money question—the earning power—is uppermost in the minds of the majority, many of the women show also a distinct ambition to equal or excel men in the work they do. Soon after the employment of women was begun in the gear department, a girl who was cutting sprockets on a gear-cutting machine became discouraged and said she was afraid

Fig. 3. Girls' Rest Room, showing Facilities for Cooking—Gas Stove in Rear. Medicine and First-aid Cabinets are on Wall in Rear of Room

Fig. 4. View of Girls' Rest Room, showing Lunch Chairs, Lockers, etc.

she could not make a success of the job. Her foreman was surprised and said to her, "We have not made any complaint as to your work, have we?" "No," she said, "but the man who worked on the night job turned out 105 pieces, while the best I could do was only 85 pieces in a day." Her foreman asked if she realized that the man on the night force was working three hours more per day than she was, and after learning this, she felt less discouraged with the results she had obtained.

It was thought when girls were first employed that practically all the setting-up work would have to be done by men, and that the girls would simply act as operators. It has been found, however, even in the short time in which the plan has been in operation, that an increasing amount of the work of setting up can be performed by the women employes. Whenever one goes through the shop, girls may be seen sharpening their own tools, and resetting them in the machines after sharpening.

In the gear department where a number of girls have been "broken in" in operating gear-cutting machines (see Fig. 1), the foreman said that they had taken hold as quickly as the average man, and some of them are doing exceptionally good and intelligent work. This has partly resulted from the girls being thrown as rapidly as possible on their own resources, being taught to set up their machines, working from a blueprint, to measure their work, and do everything that had previously been required of the operator. A criticism has recently been made of some of the departments to the effect that the foremen were giving so much supervision to the women's work that they were not thrown sufficiently on their own resources, and thus were not trained to be responsible for the work in hand. This again speaks well for the women, as showing that there is a growing appreciation of their ability to do more advanced work than had at first been expected.

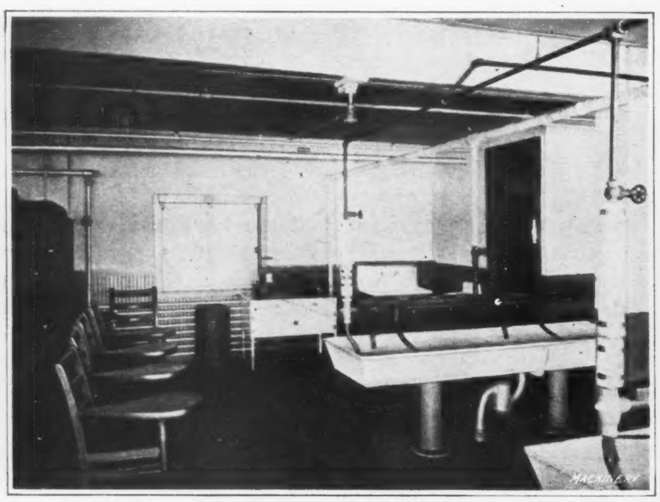


Fig. 5. Showing Gas Range and other Accommodations in Girls' Rest Room

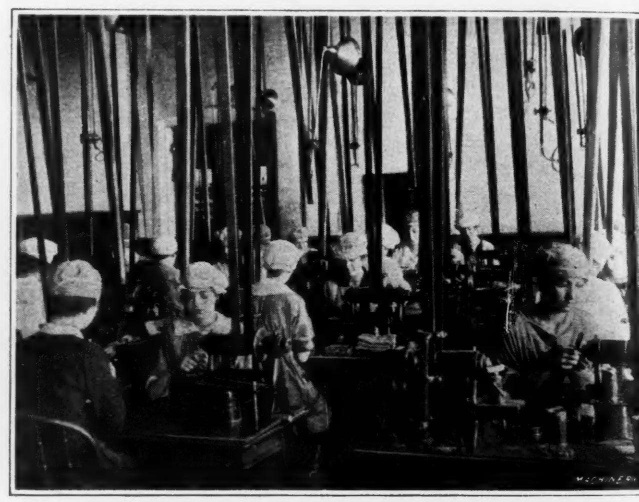


Fig. 6. Operating Polishing Machines. Girls are started on Polishing Work and advanced to Hand Tooling as they become Proficient

In inspection work, a field has been found for women in which they are making an exceptionally good showing. The chief inspector was asked whether women were learning to read the micrometer caliper. He replied that they learned to read it and read it accurately, in a very short time, and that the work passing through their hands showed much discrimination as to the points criticized. He pointed to a pile of work rejected by one of the women inspectors and said, "I have just had a man go over this work, and he has found that while the work failed to pass inspection for many reasons, they were all good reasons." He said further that in inspecting grinding work, he was surprised at the quickness with which some of his women inspectors would pick out batches of work identifying them as coming from particular workmen whose work was known to be above the average. In another department, in inspecting measuring tools, a similar condition was noted by the foreman, and he stated that one of the girl inspectors recently told him that she liked to inspect the work of Mr. Blank, because it required so few rejections. "And," remarked the foreman, "she sized the situation up just right." He also showed the writer the notes attached to a number of tools which had been held out by the woman inspector for corrections, these criticisms showing much discrimination on her part, and as good a degree of judgment as would have been expected from the experienced inspectors who had previously been doing the work. It is thus found that in the class of inspection work where women are employed the standard is not lowered because of their employment.

### Suitable Kinds of Work

The lines of work felt to be best adapted for women in the machine shop and those in which they were first given employment at the Brown & Sharpe works have been referred to. These lines have been extended to include the clerical departments of the shop, such as the routing department, stockrooms, and shipping rooms; positions as tool-room attendants; also light bench work, including riveting, filing, fitting, assembling; the operation of bench and speed lathes, drilling, milling, and grinding machines, including surface grinders; and even general machine work, such as operating engine lathes, screw machines, gear-cutting machines, etc. Their employment in some of these various lines of work is shown in Figs. 1, 2, 6, 7, and 8. Already several women are employed in the toolmaking department. One of these employes, who was operating a lathe turning out tool-steel blanks for bits and reamers, doing her own setting up and measuring, evinced enthusiasm for machine shop work, showing, in reply to questions, that her work was opening up a new field in which she took especial interest; and she remarked, "No more housework for me," with such feeling that it was evident her interests strongly leaned in a mechanical direction. Girls in the toolmaking department are working on universal milling machines, surface grinders, etc., as well as lathes. Some of the younger girls throughout the works are employed as messengers.

It was noted that the girls in one department were doing the same type of lathe work as that on which apprentices are "broken in," and the foreman was asked as to their success on this work. His reply was that they were doing just as well and learning as fast as the average boy; he then added, "Around the corner we have a girl running a planer," and from the way he spoke it was evident she was making a success of the job. This was later confirmed by the old-time mechanic who was running the adjoining planer and who was acting as her instructor. In the drafting department about twenty girls are employed, although not as draftsmen. Their duties there consist of clerical work in connection with the filing and handling of drawings, and work in the blueprint and photostat departments.

### Special Methods and Equipment for Women

It is sometimes desirable in order to obtain the best results in the employment of women to reorganize, both in methods and equipment. Thus in the screw machine department, where a man had formerly been operating four automatic screw machines, a reorganization by which he is put in charge of seven machines with a woman to help gives the required

supervision, due to his experience, and at the same time trains the woman assistant in a knowledge of the machine and its operation. In the same department it is found of advantage to use pneumatic chucks for certain screw machine operations, this being of special importance where women are employed, as it avoids the physical work of adjusting the chucks by hand, the average woman being at a disadvantage when performing such work through being shorter in stature and having a shorter reach than the average man, aside from the question of her physical endurance.

It has been found that girls who have had experience working in mills or doing other work where they have acquired qualities of endurance are better adapted for this line of work. In fact, some such previous experience, or the bringing up in a home where the father or brothers are mechanics or have had mechanical experience, gives a background which makes it more probable that a girl will adapt herself to and be successful in any line of machine shop work. A case of this kind was noted by one of our foremen; his attention was attracted by the intelligent and practical suggestions made by one of the girls as to the methods of doing her work, and, on inquiry, he learned that her father was a good mechanic and had at one time worked in our shop. As a rule, the women we have hired have had some previous experience in working for a living, although very few of them have been engaged in mechanical work. Many have been recruited from department stores. The screw machine department probably requires as much physical strength and endurance as any of the work which women have so far undertaken in our factory, and for that reason, selection of employes in this department is from those who have previously been accustomed to work requiring physical strength. It is also the job where the greatest protection is needed against accidents and also against oil and dirt.

Fig. 7. Women operating Hand Milling Machines for Manufacturing Work

Fig. 8. Bench Work in Small Tool Department, where Skill in Filing, Riveting, and other Hand Operations is developed

The screw machine department is the only one so far where skirts have been discarded. The question of wearing bloomers was presented to the employes by the foreman and they were adopted by their own decision. These garments are pronounced a success by those wearing them. In order to protect the hair, caps are worn by all machine operators. As these are of soft material, however, and do not always cover the side hair, it is not felt that they are a sure protection against the hair being caught. Experiments are being made with a very light hat frame of starched material, with wire rim, which guards the protruding hair dictated by modern fashion. The various costumes are furnished to the wearers at cost, and can be obtained through the supply department of the factory, in sizes fitted to the wearer. Short sleeves are required where the nature of the work indicates the need of such precautions for safety.

Aside from the matter of costume, it is felt that additional guarding should be used on machinery, to protect women workers. Steps are being taken to add guards in places where they were not thought necessary before. It has been strongly impressed upon each employe that there are points of danger in the machine shop, and that she should be alert and watchful to avoid them; although, in order that she may not be unduly alarmed, it is sometimes pointed out that statistics show that the shop is not so dangerous a place to work as the home. Owing to this special effort in the line of instruction, perhaps as well as to the fact that women are not employed on the whole in as hazardous operations in the machine shop as men, the accident record so far shows that they have had but four-fifths as many accidents, proportionately, as the men, and that, therefore, they have not proved to be an added hazard, as it was predicted by some that they would be. An up-to-date dispensary gives aid in cases of accident or illness to both men and women, and first-aid departments are established in all parts of the works, including the rest rooms.

### Methods of Training in Different Parts of the Country

With the pressure of war work, many steps are being taken to train workers for the industries through various lines of intensive industrial training. By the "vestibule" plan, machinery is installed at the factory in an instruction room and working conditions are simulated as nearly as possible in order to train inexperienced workers so that when they take their places in the shop they will be able to show a degree of skill from the start. Technical and industrial schools are also adopting similar plans of intensive training. The needs are so great that it will be hardly possible to overdo this matter of training. Where there is opportunity, however, for assimilating workers directly in the shop on the jobs to be done, the most direct and satisfactory results can be obtained. There is no quicker way for developing skill and making competent workmen or workwomen than on the job itself under the supervision of the foremen and workmen who have in the past been doing the work, provided they cooperate.

When showing a visitor interested in the employment of women about the works, upon coming to a number of manufacturing milling machines being operated by girls, the foreman called the visitor's attention to a particular girl and asked what he thought of the way she was working. The visitor, after watching the girl complete a cycle of operations, spoke rather enthusiastically of the efficient way in which she was handling the work, and the foreman said to him, "That girl started in new this morning."

In order for the schools to meet the needs, they also should provide, as nearly as possible, shop conditions, hours of work, discipline, regard for safety, care of machines, and all those details which, once learned, will relieve the foremen later of such elementary training. It is believed that if there are practical schools open to girls for whom there might not be a place in the shop at the moment, so that they can be trained for particular lines of work, one girl learning to operate a drilling machine and sharpen drills, another to do hand riveting, another to operate a punch press, another to attend a tool-room, and as a part of her duties to become acquainted with the sharpening of cutters and the reading of the microme-

ter caliper, so as to measure drills, stock, etc., after a short training, such girls can be recommended to the shops and will be in demand by foremen. This method should also reduce the turnover by avoiding misfits, evident failures being weeded out in the training period.

In commenting on the need of industrial training for war work before the New England manufacturers of munitions, at a recent conference, the writer expressed the thought that there are today millions of intelligent women in our American homes, either idle or inefficiently employed, who, if they felt the spur of duty and inspiration of loyalty and were led to believe that they had a part in this great movement, would quickly respond for service in the industries, to fill gaps made by the men who must go for services which the women cannot render. And with the needs now existing and in prospect, steps to more fully utilize such help should not be delayed.

### Discipline

The employment of women introduces new questions of discipline into the factory. It is important to adopt a policy from the beginning which will set and maintain a high standard, as a small number of objectionable employes of either sex can do much to offset the advantages which would otherwise be obtained from the employment of women. While it is believed to be important to have men as foremen throughout the shop, to be responsible for and instruct in mechanical work, it is also important to have matrons in each department, who will have direct supervision over groups of girls and who will act not only as counselors and helpers for them, but also be alert to prevent objectionable features creeping into the shop, by cooperating with the foremen in matters of discipline. These matrons can be occupied as producers when not otherwise engaged. For example, it was found in one department that young men were coming from other departments and stopping to visit the girls, and when steps were taken to break this up, it was found that this had been begun on invitation from the girls, who, after becoming acquainted with a young man employe, would say: "I work in such and such a department. Come and see me." This is harmless in itself, and in isolated cases, but the extension of this practice would be quickly demoralizing to shop efficiency. It is felt, also, that girls have more of a tendency to compare notes as to the pay they are receiving, as to whether they like or dislike their foremen, and other matters, and, after getting their heads together, trouble is sometimes caused which would be avoided if each attended to her own affairs. It is appreciated that these are not exclusively feminine traits.

It will be seen by reference to the accompanying table that up to the present time a slightly smaller proportion of the women who leave have been discharged than of the men who leave. When, however, the number of discharged as compared with the number hired is made the basis of the comparison, the women are materially better, as only 11 per cent of the women hired during the last year were discharged, while 17 per cent of the men were discharged. A smaller percentage of women also, as compared with the men, have been discharged on account of matters of discipline or character, which speaks well for the girls. On the other hand, the largest percentage of women are discharged because of lateness and absence, about one-half of all the girls discharged having been dismissed for this reason, which shows a lack on their part of a sense of responsibility as to regular attendance. Unsatisfactory work has been the cause of discharge of only about one-third of the total number who were discharged. Last year, out of the total number of women leaving, only 25 per cent were discharged, this being but 9 per cent of the total number employed.

| Reasons for Leaving | Men, Per Cent | Women, Per Cent |
|---|---|---|
| Discharged | | |
| Because of unsatisfactory work | 9.0 | 8.8 |
| Lateness and absence | 7.9 | 12.3 |
| For reasons of discipline | 7.7 | 3.0 |
| Miscellaneous | 1.8 | 1.3 |
| Total discharged | 26.4 | 25.4 |
| Leaving voluntarily | | |
| For other positions | 36.0 | 22.0 |
| Dissatisfied with work or pay | 20.0 | 16.0 |
| On account of poor health | 6.0 | 12.0 |
| Leaving the city | 7.7 | 3.2 |
| Change of vocation (returning to school) | 1.5 | 5.3 |
| Marriage | .... | 5.0 |
| Miscellaneous | 2.4 | 11.1 |
| Total leaving voluntarily | 73.6 | 74.6 |
| Percentage of those hired in 1917 leaving for all causes | 63.5 | 42.5 |
| Percentage of those hired in 1917 discharged | 17.0 | 11.0 |

### Turnover of Force

Although women seem to be more ready to lose time than men, they have on the whole shown more stability and have not been so ready to change their place of employment, this greater stability being shown even when taking into account the question of matrimony, where a larger percentage of women than men would naturally be expected to leave at the time of marriage. Of the total number of women hired during the last year, 57½ per cent still remained with us at the end of the year, while of the men hired during the same period, only 36½ per cent remained. Of those who left, three-fourths went within the first three months—many after a few days' or hours' employment only; this applies to both men and women. Being employed for such short periods gave little time to become skilled, so that their loss has not been felt so much. Among the reasons for women leaving voluntarily, nearly one-third were to take other positions; one-fifth because they were dissatisfied with their work or pay; and one-sixth on account of poor health, this being a larger proportion than of men leaving because of poor health. Miscellaneous reasons accounted for the remainder.

In investigating the relation of the nationality of women to turnover, it may be noted that up to the present time a large proportion of our force has been drawn from the English-speaking races. Employes of this class, however, have shown practically the same proportion leaving as of the non-English-speaking peoples, although a somewhat larger proportion of the latter were among those discharged. It will be understood in referring to employes of the non-English-speaking races that all such women in our employ are able to speak English. Of the English-speaking races, judging from figures based on the limited data at hand, the American girls have not proved as stable as the Irish and Scotch, although more so than the English and Canadians. Among the non-English-speaking races, the Italians and Jews have shown the lowest percentage leaving. The following table gives the general comparison, and shows in the first column the relative proportion for each nationality of those leaving who have left voluntarily, and the second column the same for those discharged, while the third column shows the proportion of each nationality who left of the total number hired.

**NATIONALITY IN RELATION TO TURNOVER**

**Women Hired in 1917 and Leaving During Same Year**

| Nationality | Per Cent Leaving Voluntarily | Per Cent Discharged | Per Cent of Total Leaving |
|---|---|---|---|
| American | 71 | 29 | 38 |
| English and Canadian | 78 | 22 | 44 |
| Irish | 75 | 25 | 22 |
| Scotch | 80 | 20 | 25 |
| Total English-speaking races | 72 | 28 | 37.2 |
| French and French Canadians | 69 | 31 | 59 |
| Swedes and Norwegians | 62 | 38 | 47 |
| Italians | 60 | 40 | 33 |
| Jews | 67 | 33 | 21.5 |
| Russians | 100 | .. | 38.3 |
| Miscellaneous | 50 | 50 | 50 |
| Total non-English-speaking races | 71 | 29 | 37.6 |

Some facts have also been obtained to show the relation of age to turnover, and these show that a larger percentage have left of those between twenty and forty years of age than those younger or older. The comparatively few hired who were over forty years of age (as reported) have shown the lowest turnover. The percentage discharged, however, has been about the same for all ages.

There has been no bar to the employment of married women, as has been reported to be the case in some factories, and some of the most satisfactory employes are from among this class. It is believed, however, that it is too severe a strain for women to endeavor to carry full home duties with employment in the shop, and that employment should not be given in cases where this would be necessary. It has been noticed that married women sometimes seek employment for a short time only with the view, in some cases apparently, of earning a certain amount of money for a purpose they have in view, and when that is attained, to either leave or to show indifference to their work, so that their services become unsatisfactory, not because they cannot do good work, but because the incentive has been removed. Such cases, however, are not the rule.

### Relative Cost of Work

Besides the points already mentioned which add to the cost of employing women, such as extra provision for their comfort, supervision, employment of matrons, etc., the fact that the girls work shorter hours allows the machines to stand idle for a greater portion of the time, and thus reduces production, as compared with employing men for the same work. Their shorter hours necessitate hiring more girls and taking more shop space for the same amount of production. These drawbacks, however, are being largely offset by the results obtained as the girls become experienced.

The shorter hours worked by women employes make it possible to arrange for them to leave work before the men do, both at noon and night, a precaution which is felt to be of advantage in avoiding confusion and any tendency to annoyance which might otherwise creep in.

While, as has already been pointed out, the money question is the strong incentive with most women, it has been found that in some departments, especially where the younger girls are employed, if they earn a certain amount a week, they are satisfied, and it is difficult to make them put forth the effort necessary for increased production. This may be due in some cases to the fact that the pay envelope is taken home and turned over to the parents, and it makes no direct difference to the girl whether she earns more or less.

It will be understood that the foregoing is based on a limited experience only in the employment of women, and that many of the views here expressed and statistics given may change in the light of further experience and show quite different results from those here pointed out. The matter is presented at this time because it is felt that there is now an urgent need, and one which will grow more pressing, of maintaining and increasing the working forces in the industries essential to the winning of the war, and that there is no time to be lost in putting into operation such measures as will be of direct help in attaining that end. It is believed that there is no present source of labor supply so promising or so important to develop as the employment of women, and whatever can be given to the public that will be in any way helpful in either starting or extending the employment of such help and making it fully successful will be of especial service at this time.

* * *

In his inaugural address as president of the British Institute of Bankers, Sir Richard V. Vassar-Smith, chairman of Lloyd's Bank, Ltd., said that means would be found for a better remuneration of labor sufficient to provide a higher standard of living, with shorter hours of work and better housing, and, in addition, a share of the profit after providing a proper return on the capital employed, with reserves for depreciation and betterment. He said it was wrong to believe that low-paid labor is necessarily economical or that a high rate of wages is a handicap in competing for the markets of the world.

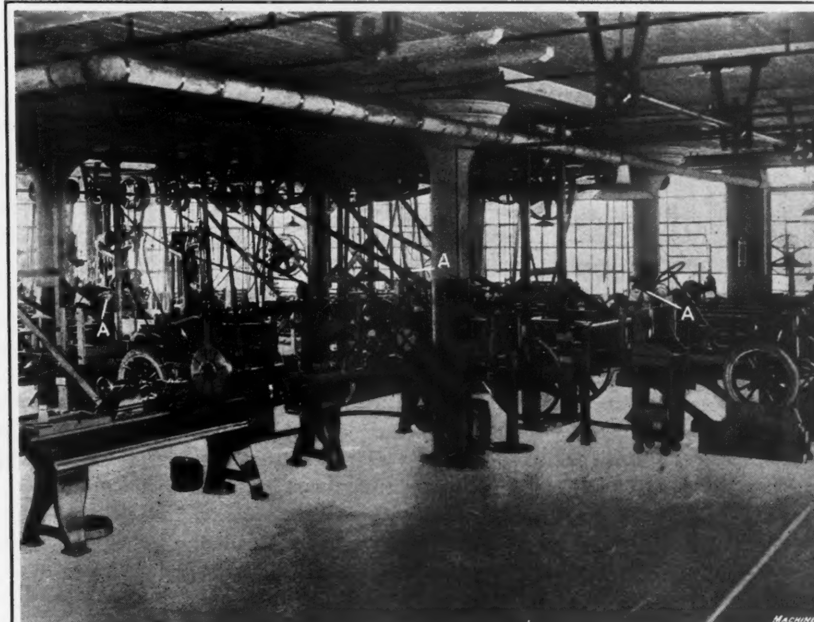
## USING AUTOMOBILES FOR DRIVING MACHINERY

The accompanying illustration shows a machine shop in which three automobile chassis *A* drive the lineshaftings that run the machinery, because the electric power company had to shut down on account of lack of coal. The automobile chassis were mounted on blocks and the rear wheels replaced with pulleys, which were belted up to the lineshaft. Not only was all the machinery run very satisfactorily by this method, for several weeks, but power was furnished the air compressor and elevators. C. C. S.

* * *

## LOADING AND GLAZING OF A GRINDING WHEEL

The difference between glazing and loading of a grinding wheel is not always clearly understood. A loaded wheel, as defined by *Grits and Grinds*, is one to the face of which particles of the metal being ground adheres; that is, one in which the openings or pores of the wheel face have been filled with metal, leaving no room for clearance. The presence of a number of these pieces of metal on the face of a wheel prevents the wheel from cutting into the work, and the loaded places create heat. On a glazed wheel, the cutting particles have become dull or worn down even with the bond, the bond being so hard that it does not wear away fast enough to allow spaces between the cutting particles nor to allow the cutting particles to escape when dulled. In a glazed wheel, the cutting particles and the bond at the extreme surface of the wheel are of the same radius. A wheel will not load unless the bond is too hard or unless it is run very much too slow. Glazing may indicate that the wheel is too hard for the work or that it is running too fast. One remedy for loading is to increase the speed; a remedy for glazing is to decrease the speed. If the speeds are right, a softer wheel should be used in either case. Loading and glazing make excessive dressing necessary, and excessive dressing wears wheels faster than grinding. In rough-grinding, were it possible to obtain an ideal wheel for the work, dressing would not be necessary, theoretically, as the face of the wheel would automatically sharpen itself.



Unusual Method of driving Machines in Machine Shop

* * *

## TESTING MANILA ROPE

A method for testing manila rope has been developed by C. E. Swett, of the Arthur D. Little, Inc., Laboratories, Cambridge, Mass. This test has been adopted by the United States Bureau of Standards. Briefly, it consists in freeing the rope from oil, soaking it for twenty seconds in a solution of bleaching powder acidulated with acetic acid, rinsing in water and then in alcohol, and finally exposing the fibers of the rope for a minute to the fumes of ammonia. Manila fiber turns russet brown, while all other rope fibers turn a cherry red.

# MACHINERY

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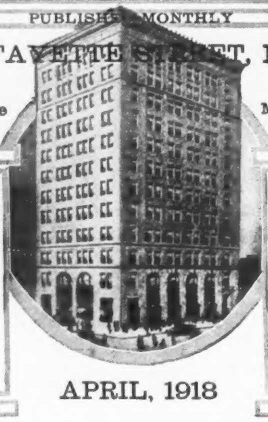

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.


## THE PROBLEM OF TRANSPORTATION

Most manufacturers used to consider transportation none of their business. Its problems, they argued, were problems for railroad officials. Now, however, we know that transportation is everybody's business. Every manufacturing industry is fundamentally dependent upon transportation. The last few months have taught us that. Yet how many manufacturers have done anything toward proper cooperation with the transportation systems? Railroad cars are kept idle on sidings for days. They are used for the storage of manufactured articles and raw materials. They are held, loaded with coal, on sidings and in yards for days, instead of being immediately unloaded and made available for further service.

Payment of demurrage charges absolves nobody from responsibility for holding up railroad cars. They are the most vital necessity of our whole industrial system. It is every manufacturer's business to plan in such a way that he will never cause railroad cars to remain idle. He must cooperate to the limit of his power with the railroads. Thus will the problem of transportation congestion be half solved.

* * *

## WOMEN WORKERS IN MACHINE SHOPS

Is the increased employment of women in machine shops a desirable development? To give a definite answer now would be premature. What can be said, however, is this: Such employment of women seems to be necessary on account of the abnormal conditions created by the war. Much has been written about the success achieved by women workers in British machine shops. Women are now employed in Great Britain on all classes of machine work, and the working force on such high-class work as the making of fuses is almost entirely composed of women. In some kinds of work, it is maintained, they have proved superior to the men formerly employed.

The fact that huge numbers of men are now serving the nation in the war, coupled with the expansion of those industries in which men workers are essential, has induced many American manufacturers to employ women where only men were employed in the past. This is being done quite extensively in munition plants, and in some of the large machine tool building plants it has also proved successful. In forming a judgment as to the desirability of so employing women, one must bear in mind that things must be done in time of war that would have occurred to nobody in time of peace. What has been established so far is that the women have proved satisfactory in the work to which they have been assigned and that they can, by doing such work, assist actively in making the materials which will win the war.

* * *

## WATER POWER INSTEAD OF COAL

The stationary power plants of the United States, according to one authority, generate 49,000,000 horsepower and use 30 per cent of all the coal mined in the country. Secretary of the Interior Lane has estimated that 35,000,000 horsepower may be obtained from the nation's wasted water power; only 6,000,000 horsepower is now being generated hydraulically. In other words, should the country's wealth of water power be fully developed, more than two-thirds of the fuel now used to generate power—a total of 139,000,000 tons—would be saved. Not only that—380,000 men now required for mining, transporting, and firing this coal would be released for other work, only 40,000 men being required for the hydraulic plants. Nearly 200,000 railroad cars and 5000 locomotives would be set free.

The thing to do with water power is to develop it. Whatever retards or restricts its use on terms fair to the public is contrary to public policy, hostile to the nation's best interests. The Administration's Water Power Bill, which is before the present Congress, not only safeguards the people's interest in a most valuable natural asset, but provides for its proper development. Granting to private interests the right to develop national water power upon terms that are fair to all concerned is one of the most important among the industrial problems that now demand solution, since it affects materially the question of saving of coal. The present coal shortage, it must be borne in mind, instead of being merely incident to the war, is a condition that will affect to some extent the development of the country's industries for some time in the future.

* * *

## SAVING CAST IRON VS. SAVING TIME IN MACHINING

Machine designers generally seek to reduce to the minimum the amount of material used in a machine or device, without, of course, impairing the strength or spoiling the appearance. This makes for cheaper production, as it eliminates unnecessary metal, every ounce of which means waste; and if there is one thing that should be impressed before others upon Americans today it is to avoid waste. But there is another side of this question: If saving a few ounces or pounds of material means more costly machining equipment, more hours in the machining of parts, then it is not true economy. Sometimes such false economy reduces the metal in castings to such an extent that the surfaces spring away from the tool during machining, necessitating special methods to prevent distortion. In other cases the effort to save a small amount of cast iron means the introduction of difficult foundry work. The whole thing comes down, after all, to a matter of judgment on the part of the designer, who must have experience enough to determine just how far he can go in saving metal without increasing expenses in the foundry and machine shop.

Generally those designs are best in which the machine designer, the tool designer, and the practical shop man have worked together, so modifying the design that the production cost is kept low without sacrificing any of the essential features of the design. If the designer is more of a shop man than an engineer he is likely to think of production only and sacrifice some of the engineering features of the machine in order to facilitate production. His error is more serious than that of a designer who, though he produces a good machine, neglects to consider the methods of molding and machining, because excellence in the product is the prime requisite. The machining processes are merely a means to an end.

The ideal designer is a man with good practical judgment, able to balance the different problems against each other, capable of producing a machine which can be manufactured cheaply and yet retain all the qualities desirable from an engineering point of view.

# How Much are American Institutions Worth to You?

HOW much are American institutions worth to *you?* That is the question that every American will be asked in the next few days, and he must answer it, not in flowery words and high-sounding phrases, but in dollars and cents. He must answer it by the figures above his signature on his Liberty Bond subscription blank. It will be an answer that will ring around the world—an answer that will give Kaiserism, militarism, and autocracy something to think about.

How much are American institutions worth to *you?* That is the question that you must answer, whatever your station or condition in life; whether employer or employe, whether skilled or unskilled, whether native born or of foreign extraction, whether man or woman. How much is it worth to you to live under the institutions that have developed in this Republic? How many of your present pleasures, luxuries, or comforts are you willing to sacrifice for the safeguarding of American liberties? How large is your subscription for Liberty Bonds going to be?

You, Mr. Manufacturer, how much are American institutions worth to *you?* Will you respond not only with the surplus of present prosperity, but also with capital that you could more profitably invest elsewhere? Is it a sacrifice or is it a privilege to you to be among those who are able to respond to the call of your country in a greater measure than the great mass of citizens? Are American institutions to you worth the sacrifice of present profits in order that these liberties may remain forever secure in the future? To that question there can be but one answer. But, as an employer, a double duty and a double privilege are yours. It is for you to fire the enthusiasm of the hundreds or the thousands of men and women engaged on your work. In doing so you can meet them on common ground, for, in safeguarding American institutions, you and they are partners. You can encourage, you can stimulate, you can develop a spirit that will completely answer the question of how much American institutions are worth to every man and woman in your works in an unmistakable manner.

And you, Mr. Employe, how much are American institutions worth to *you?* When the cost of living is high and the present mode of living absorbs nearly all that you can earn, are you willing, for the sake of American institutions for yourself, your family, and your children, to change that mode of living for the time being? Are you willing to sacrifice most of the small luxuries and comforts that you have enjoyed, in order that you may help to safeguard the institutions that have grown up under the Stars and Stripes? Remember, these are days of sacrifice. The man who thinks that he can walk along in the usual way in this world upheaval will find that he is mistaken. Whether you earn little or much, there is something that you can spare, something that can go into a Liberty Bond.

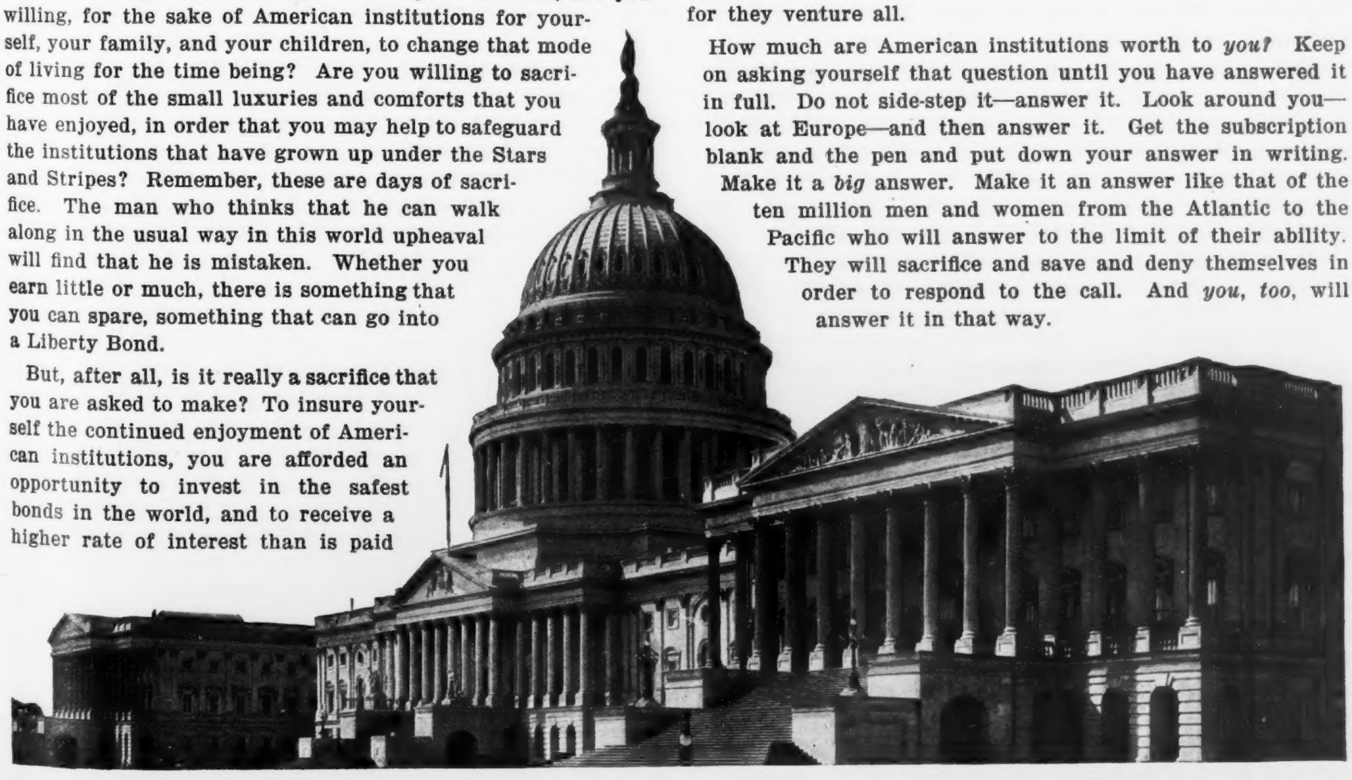
But, after all, is it really a sacrifice that you are asked to make? To insure yourself the continued enjoyment of American institutions, you are afforded an opportunity to invest in the safest bonds in the world, and to receive a higher rate of interest than is paid by any other institution offering absolute safety for your money. You lose nothing—for some day you will have your money with interest to enjoy and to spend, at a time when the cost of living will be less and when you will receive a great deal more for your money. Purely as a business proposition, is not that worth while?

What if Germany should win this war? If that happens, you will not be asked how much American institutions are worth to you; but you will help pay the indemnity, and there will be no repayment of the principal, nor will there be any interest. Even if Germany does not win and there is a peace by negotiation, what then? The world will remain an armed camp ready for the day when militarism and autocracy will again attempt to conquer. American institutions as we have known them will be a thing of the past; we, too, must be armed to the teeth, the burden of armaments will rest upon us, universal military service will become a fixed national policy, and militarism, with all that it implies, must be accepted. The choice is yours.

Some day, when the war is a thing of the past, when the horrors of the hour have faded away and the sun again shines over a peaceful world, you will think back upon the day when you were asked: "How much are American institutions worth to you?" Would you not then like to be able to say, "When the call came, I responded to the limit of my ability"; or will you say, "Others fought and sacrificed, but I shirked it all"?

Over there, hundreds and thousands of our countrymen are answering the question of how much American institutions are worth to them. They have placed the supreme value on these institutions; they are willing to defend them by making the supreme sacrifice. And here are we, safe behind the double lines of navies and armies, debating how much these institutions are worth to us. This is the answer: They are worth all the material things we have; they are worth all the luxuries and the comforts, the automobiles and the diamonds, the fancy clothes and expensive foods—everything above the very necessities. If we are not willing to answer the question in that manner, we are cowards hiding behind our soldiers, willing to reap the benefit, but not willing to make what is only a slight sacrifice compared with that which they are making, for they venture all.

How much are American institutions worth to *you?* Keep on asking yourself that question until you have answered it in full. Do not side-step it—answer it. Look around you—look at Europe—and then answer it. Get the subscription blank and the pen and put down your answer in writing. Make it a *big* answer. Make it an answer like that of the ten million men and women from the Atlantic to the Pacific who will answer to the limit of their ability. They will sacrifice and save and deny themselves in order to respond to the call. And *you, too,* will answer it in that way.



# THREAD ROLLING[1]

**FIRST INSTALLMENT OF A SERIES ON DIFFERENT METHODS OF FORMING SCREW THREADS BY ROLLING, VARIOUS TYPES OF THREAD ROLLING MACHINES ADVANTAGES OF ROLLING PROCESS AND GENERAL APPLICATION**

BY FRANKLIN D. JONES[2]

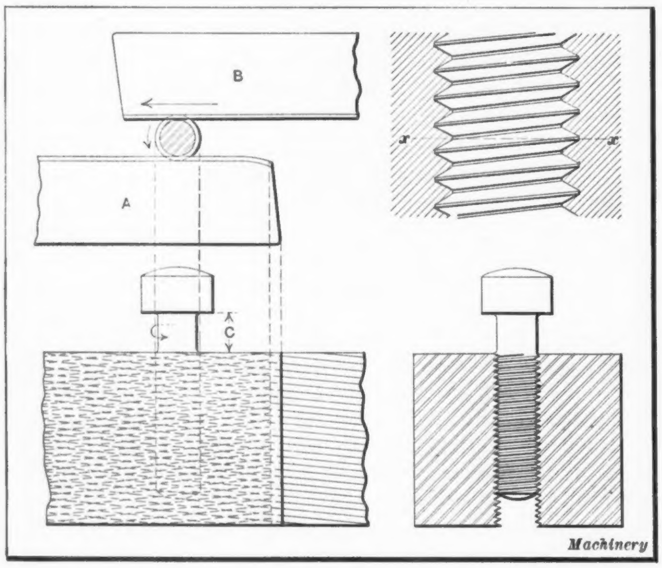



Fig. 1. Diagram illustrating how Screw Thread is rolled between Flat Dies

THE rolling process of forming screw threads may be defined as an impression or displacement method, since the thread grooves are not cut by an edged tool, but are formed by means of a die or roll having threads or ridges which are forced into the metal and, by displacing it, produce a thread corresponding to the required shape and pitch. The plain blanks upon which threads are to be rolled are somewhat smaller in diameter than the finished thread, because when a thread is rolled a certain amount of metal is displaced and is forced up above the original surface of the blank, thus producing a screw thread which is larger in diameter than the original blank. The increase in diameter is approximately equal to the depth of one thread. No material whatever is removed by the rolling process, the metal from the depression formed by the die simply being forced up on each side.

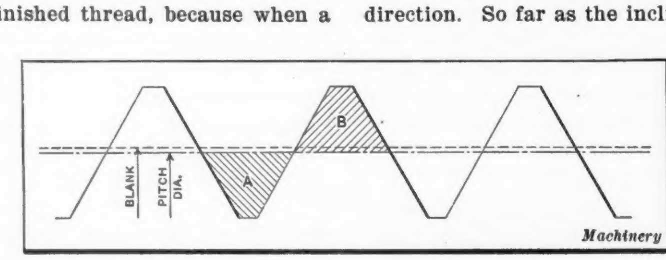



Fig. 2. Diagram showing Relation between Diameter of Blank and Pitch Diameter of Rolled Screw Thread

Screw threads may be rolled (1) by using a circular disk or roll having a threaded periphery, or (2) by rolling the blank between dies which may be either flat or circular in form. The circular roll is employed when screw threads are rolled on automatic screw machines or turret lathes, and the dies referred to are used when thread rolling is done by means of machines designed exclusively for this work. Thread rolling is done in automatic screw machines when a thread is required behind a shoulder or other intervening part, which makes it impossible to cut it by using a regular thread-cutting die. The advantage of rolling the thread in such cases is that a second operation is avoided. The important commercial application of the thread rolling process is found in the shops and factories using machines designed especially for this work. These machines are extensively employed in certain lines of manufacture for threading such parts as bolts, screws, studs, rods, etc., especially where such threaded parts are required in large quantities. Screw threads that are within the range of the rolling process may be produced more rapidly by this method than in any other way, which accounts for the use of thread-rolling machines in connection with bolt and screw manufacture and wherever thousands of duplicate threaded parts are required. After describing the method of forming a thread by rolling a cylindrical blank between flat dies, some of the different designs of thread-rolling machines and their method of operation will be considered.

### Thread Rolling between Flat Dies

Most of the machines designed exclusively for rolling screw threads are equipped with flat dies. There are two of these flat dies on a machine, as shown by the diagram Fig. 1, which illustrates the general principle of this method of rolling threads. One die *A* is stationary and the other die *B* has a reciprocating movement. The faces of the dies have parallel grooves and ridges of practically the same cross-sectional shape as the thread to be rolled, and are spaced to correspond with the required pitch. These ridges, which represent a development of the thread the dies are intended to roll, incline at an angle equal to the helix angle of the thread, so that as the screw blank rolls between the two dies, a screw thread of the same pitch and helix angle is reproduced on it. The thread is formed in one passage of the bolt, rod, or other part to be threaded, the work being inserted at one end so that it simply rolls between the die faces until it is ejected at the other end. The ridges on both dies incline in the same direction when viewed from the rolling sides or faces, but when the dies are in the thread-rolling machine, the ridges incline in the opposite direction, and are, therefore, in alignment with the thread groove on the work at the two lines of contact. The face of a die for rolling a right-hand thread is shown at *A* in Fig. 3. The die shown at *B* is intended for a left-hand thread, and for that reason the ridges incline in the opposite direction. So far as the inclination of the ridges is concerned, each of these dies is a duplicate of its mate, as seen from the face side.

### Relative Positions of Dies and Work

The relation between the position of the dies and a screw thread being rolled is such that the top of the thread-shaped ridge of one die, at the point of contact with the screw thread, is directly opposite the bottom of the thread groove in the other die, at the point of contact, as indicated by the line x–x of the enlarged sectional view, Fig. 1. This relation between the dies and the screw thread must be maintained throughout the thread-rolling operation, and it is essential to start the work between the dies when the movable die is in the right position. If the blank to be threaded is

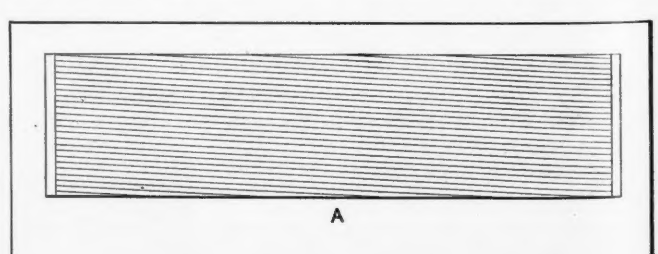



Fig. 3. (A) Die for rolling Right-hand Threads. (B) Die for rolling Left-hand Threads

[1] For other articles on the production of screw threads, see "General Thread Cutting Practice," March, 1918, and articles there referred to.
[2] Associate Editor of MACHINERY.

started at exactly the right time, the groove rolled into it by one die will engage or match with the ridges on the other when the blank has turned a half revolution; therefore, since the two dies engage the screw thread on opposite sides and as one-half turn of the screw corresponds to one-half the pitch, the ridges on one die must be one-half the pitch above or below corresponding ridges on the other in a plane intersecting the axis of the threw thread being rolled.

In order to form the thread gradually, the two dies may not be set exactly parallel, but a little farther apart at the end where the rolling operation begins, so that, as the screw blank moves from the starting end through the dies, the thread is formed by a progressive rolling action. This method of setting is sometimes reversed, the dies being set a little closer together at the starting end. A full thread is then formed more rapidly at the beginning of the rolling operation. The object is to form the thread as quickly as possible so that there will be comparatively little pressure between the work and the die during the remainder of the stroke in order to obtain a planishing effect and a smooth finish. There is a difference of opinion among the users and manufacturers of thread-rolling machines regarding the relative merits of these two methods of adjusting the dies. In any case, the adjustment from a parallel position is very slight.

Thread-rolling machines are equipped with some form of mechanism which insures starting the screw blank at the right time and also square with the sides of the dies. These machines differ in regard to the position of the dies and the arrangement of the mechanisms which operate the moving die, the blank starting device, and other parts. Machines of this general class also vary in that some have automatic blank feeding mechanisms, whereas others of simpler construction require the constant attention of an operator for feeding each blank between the dies by hand.

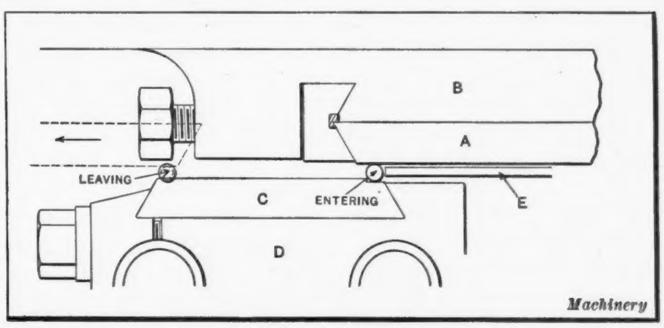



Fig. 6. Plan View of Thread-rolling Dies

**Diameter of Screw Blank before Thread is Rolled**

The diameter of the blank or cylindrical part upon which a thread is to be rolled should be less than the required screw diameter by an amount that will just compensate for the metal that is displaced and raised above the original surface by the rolling process. If the screw blank is too large before rolling, there will be an excessive amount of metal and the screw will be larger than the standard size. On the other hand, if the blank is too small, either an incomplete thread will be formed or, if the dies are adjusted to roll a full thread, the diameter will be smaller than standard. While the blank diameter can be determined mathematically, it may be necessary to make slight changes in the calculated size in order to secure a well-formed thread. If the diameter is first calculated by using a rule or formula which is known to be at least approximately correct, the results should be verified by actual trial if possible. The importance of determining accurately what blank diameter is required to form a full or complete thread depends somewhat upon the class or quality of the threaded work. For instance, in some plants where screw threads are rolled on ordinary bolts, etc., it is the practice to use blanks that are slightly smaller than the pitch diameter of the screw thread, and in many cases the threaded ends of the screws or bolts are a little smaller than the standard diameter, so that nuts tapped with standard taps will screw on easily. A full thread may be formed when using a blank that is less than the pitch diameter, but if this is done, the screw will be slightly under size. When completely formed screw threads of standard diameter are required, the blanks must be a little larger than those used on the less accurate classes of work.

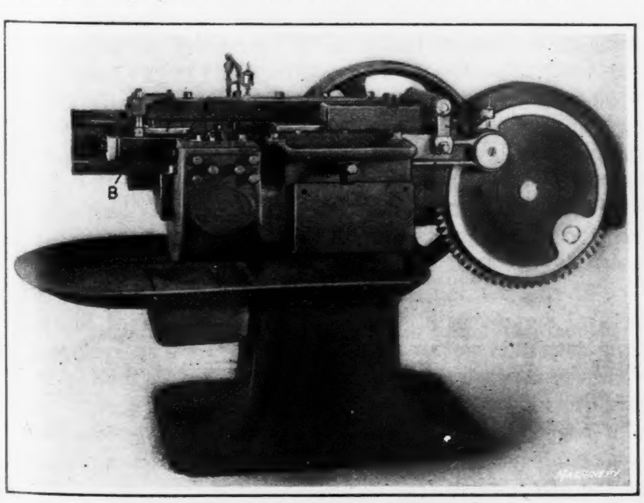



Fig. 4. Reciprocating Type of Screw-thread Rolling Machine arranged for feeding Blanks to Dies by Hand

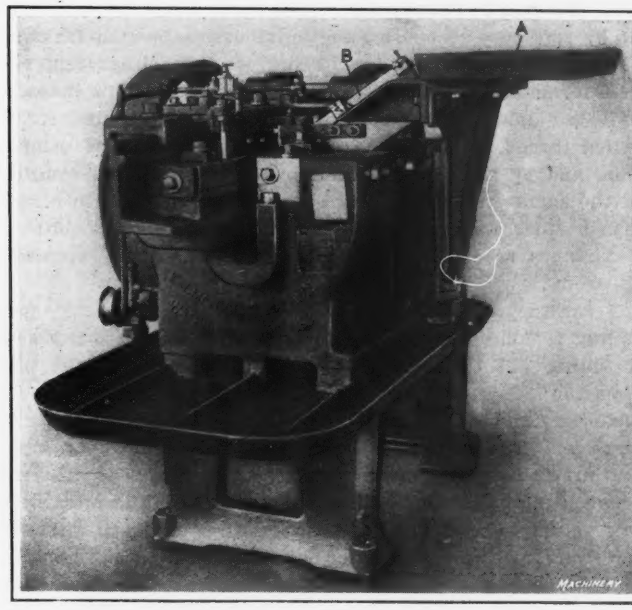



Fig. 5. Reciprocating Screw-thread Rolling Machine equipped with Semi-automatic Feeding Mechanism

Aside from the question of accuracy, the blank diameter is affected to some extent by the nature of the material of which the screw blanks are made; that is, whether it is hard and offers considerable resistance to displacement, or is soft and easily formed by the threading roll. For instance, threads may be rolled in either brass or steel, but the action of brass is different from that of steel. The condition of the surface of a steel blank may also affect the diameter. When a thread is rolled on drawn stock, there is little, if any, compression of the metal as it is displaced to form a thread, because the surface is already quite dense as the result of the cold-drawing operation. If this dense outer surface, however, is removed by a cutting tool, the metal will be subject to slight compression as it is displaced; consequently a larger blank diameter is required for a turned piece than for one which was drawn to size. Brass blanks for screws of a given size should be a little larger than those made of steel for the same reason; that is, because there is a slight compressive effect and need for a little more stock to offset this action. The variations in blank diameters due to this cause are very slight, but should not be disregarded if accurate thread rolling is to be done.

The blank diameter may be determined quite easily by actually rolling threads on blanks the sizes of which are changed as may be required to produce a well-formed thread. While this is the most reliable method, it cannot always be applied, as the stock from which the blanks are to be made sometimes is not at hand; in fact, it may be necessary to order the stock from the mill long before it is needed, and

then the blank diameter is either determined by calculation or by reference to blank sizes previously tabulated for different screw thread diameters. There are several different rules and formulas for calculating blank diameters, but inasmuch as this diameter is affected by the accuracy required for the rolled thread, the kind of material to be rolled, its composition, and by any decided variation in the physical condition of the surface metal (as, for example, when the skin of cold-drawn stock is removed by turning), the impracticability of deducing a rule or formula that may be generally applied is apparent.

According to the practice in different plants where thread rolling is done, there are three general classes of blank sizes, including (1) those that are a little larger than the pitch diameter; (2) those that are approximately equal to the pitch diameter; and (3) those that are slightly less than the pitch diameter. The sizes in the first class are intended for screws that are to be rolled as accurately as possible. The difference between the blank diameter and the corresponding pitch diameter varies somewhat for screw threads of different sizes, but according to average practice, as near as this can be determined, the relationship is about as follows: The blank diameters for screws varying from 1/4 to 1/2 inch are from 0.002 to 0.0025 inch larger than the pitch diameter, and for screws varying from 1/2 to 1 inch or larger, the blank diameters are from 0.0025 to 0.003 inch larger than the pitch diameter. Threads of the second class mentioned, or those rolled from blanks which are equal to the pitch diameter, are sufficiently accurate for many purposes. Blanks of the third class or those that are slightly less than the pitch diameter are intended for bolts, screws, etc., which are made to fit rather loosely, a comparatively free fit being desirable in many cases. Blanks for this grade of work, according to common practice, are from 0.002 to 0.003 inch less than the pitch diameters for screw threads varying from 1/4 to 1/2 inch, whereas for screw thread sizes larger than 1/2 inch the blank diameters are frequently from 0.003 to 0.005 inch less than the pitch diameter. The blanks for screw threads smaller than 1/4 inch are usually from 0.001 to 0.0015 inch less than the pitch diameter for ordinary grades of work, and about the same amount larger than the pitch diameter for more accurate screw threads.

The reason why the blank diameter should be somewhat larger than the pitch diameter when a full thread of standard size is to be formed is that the volume of the thread groove extending inside the pitch line or surface as at *A*, Fig. 2, is less than the volume of the section *B* of the thread extending outside the pitch surface, the mean radius of section *B* being larger than the radius of *A*. If the blank is made somewhat larger than the pitch diameter, as indicated by the dotted line marked "blank," this will offset the difference between the volumes of sections *A* and *B*.

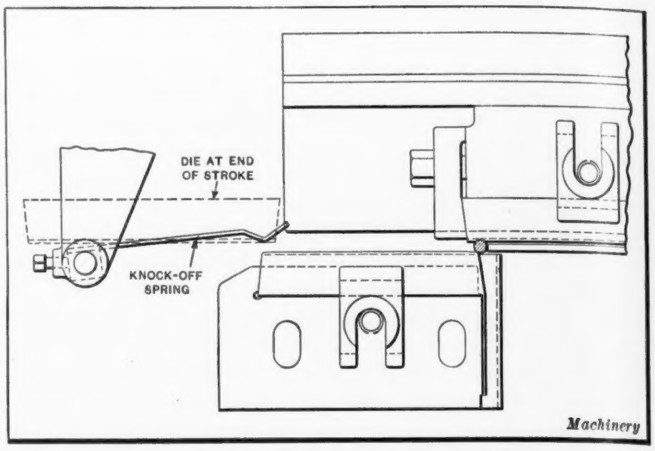



**Fig. 8. Plan View showing Relation between Thread-rolling Dies and Knock-off Spring which ejects Threaded Blank at End of Stroke**

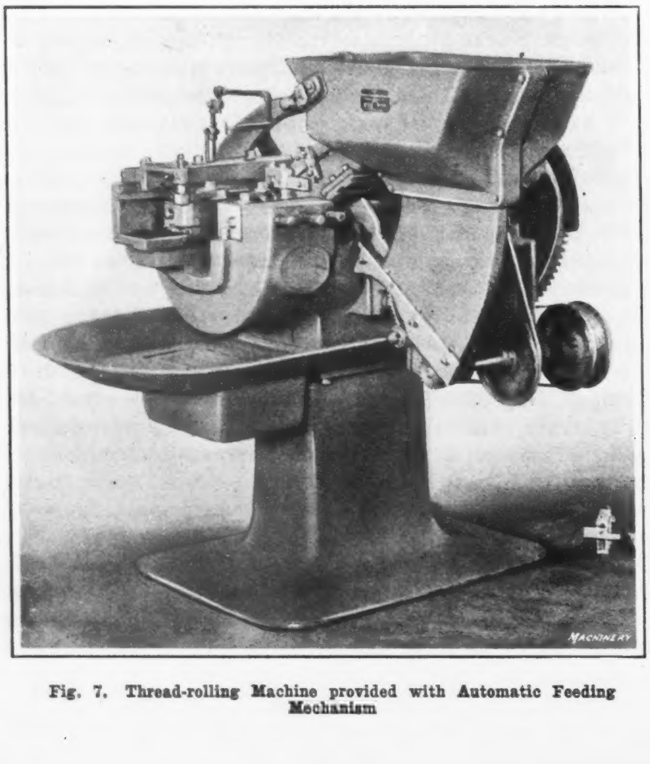


**Fig. 7. Thread-rolling Machine provided with Automatic Feeding Mechanism**

#### Reciprocating Thread-rolling Machines of Horizontal Design

The thread-rolling machine illustrated in Fig. 4 is a horizontal type which operates on the general principle illustrated by the diagram Fig. 1. This machine is one of the designs and sizes manufactured by the Waterbury Farrel Foundry & Machine Co., Waterbury, Conn. The stationary die is securely held at *A* and the movable die *B* is attached to a slide connecting with pitman *C*. This pitman is operated by a large crank gear *D*, which is driven from a pinion mounted on the driving pulley shaft. This particular machine is arranged for feeding the blanks by hand, so that it is comparatively simple in design. The blanks to be threaded are placed, one at a time, in the feeding position, the lower end resting against a stop, which may be adjusted vertically and insures rolling threads of equal length on the different blanks. Each blank is placed in position, while the slide is returning, and when the moving die has advanced to the right position relative to the stationary die a push-finger starts the blank between the dies. As soon as the blank is caught, it is rolled along between the die faces until it has passed entirely across the stationary die; the thread-rolling operation is then completed and the bolt or screw falls into a receptacle. The push-finger is operated by a cam located on the opposite side of the machine from that shown in the illustration. This cam transmits motion through a shaft and lever *E* to the slide carrying the push-finger or "starter," as it is sometimes called.

When exceptionally long blanks are being threaded, a special holder or clip is applied to machines arranged for hand feeding to insure locating the blanks square with the dies. In rolling threads on shorter blanks, such an auxiliary device is not necessary, because the vertical face of the push-finger tends to start a blank square, even though it may be slightly inclined when the push-finger moves forward. On some of these machines, the movable die has a vertical concave groove or pocket cut across the teeth or ridges near the starting end. This groove, which has a depth approximately equal to one-half the thread depth, is opposite the end of the fixed die just before the rolling operation begins, and the blank enters it as the push-finger advances. The purpose of this vertical groove or pocket is to insure starting each blank square with the dies.

Another screw-thread rolling machine of the horizontal reciprocating type is shown in Fig. 5. This is one of the designs made by the E. J. Manville Machine Co., Waterbury, Conn. The driving mechanism of this machine is quite similar in its general arrangement to that previously described in connection with the machine shown in Fig. 4. The reciprocating slide which carries the movable die receives its motion from a large crank gear, as in the former case, which meshes with a pinion on the flywheel shaft. The crank gear is connected to the reciprocating slide by a pitman. This machine is known as the direct drive type to distinguish it from earlier designs having a crank gear revolving about a vertical axis and driven

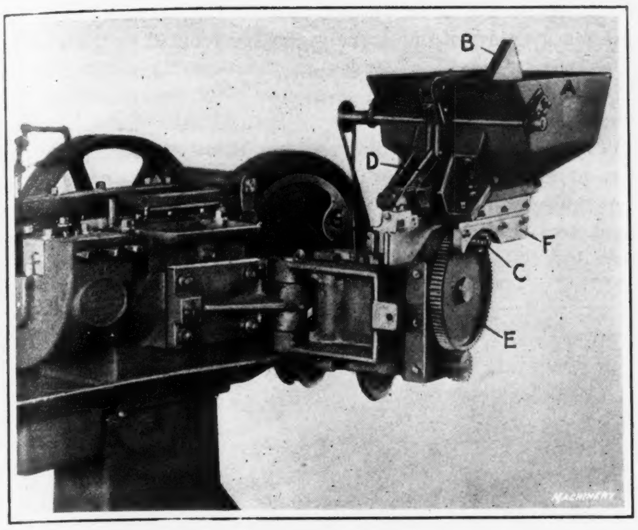



Fig. 9. Feeding Mechanism of Machine shown in Fig. 7 swung out of the Way to permit Hand Feeding

through bevel gearing from a horizontal shaft connecting with the belt pulley. The arrangement of the stationary and moving dies and the method of starting each screw blank between the dies at exactly the right time is shown by the diagram Fig. 6, which represents a plan view. The moving die *A* is carried by the reciprocating slide *B*, and the stationary or short die *C* is clamped into an adjustable holder *D*. This holder may be adjusted toward or away from die *A*, as may be required by the diameter of screw thread to be rolled. The moving die is shown at one end of its stroke. As die *A* moves toward the left, the blank to be threaded is pushed between the two dies by the starter *E*. This starter or push-finger ordinarily is operated by an adjustable cam, which transmits motion to it through a mechanism so arranged that either a positive or yielding pressure may be given to the blank as it enters between the dies.

At the starting end of die *C* there is a short blank space which is cut down level with the bottom of the grooves in the rest of the die face. This provides room for inserting a blank and enables another blank to be placed in position as soon as starter *E* has withdrawn far enough, without danger of the second blank being dragged in by the moving die before the latter is in position to receive it. It is, of course, essential to have the dies properly located relative to each other, and the action of the starter must also be timed so that the blank is pushed forward at the right instant.

### Adjustment or Timing of Starter

The starter on the Manville machines is set by first placing the moving slide at the extreme end of its stroke toward the right and then moving it forward about one-eighth inch. The starting cam is then set on its highest point and the starter is adjusted endwise until its end is in line with the ends of the threads on the stationary die. After these approximate adjustments have been made, a blank is inserted in front of the starter and the machine is turned far enough to revolve the blank forward about half a revolution. The machine is then turned backward and the blank removed to see if the thread rolled by one die coincides with those rolled by the other die. If the thread grooves do not match properly, the position of the starting cam is changed so that it acts either earlier or later, thus forcing the blank between the dies when the latter are in the correct position relative to each other. Another method of remedying this trouble is by raising or lowering one of the dies slightly.

### Ejector or Knock-off of Thread-rolling Machine

Bolts or screws sometimes stick to the movable die after the thread is rolled. In order to prevent a screw from being caught between the dies on the return stroke, the simple form of knock-off or ejector shown in Fig. 8 is used. A flat spring having a bent end is attached to the frame of the machine in such a position that the screw forces the spring back while it is still between both dies and is firmly held. When the spring returns to its normal position it pushes the blank forward and away from the movable die so that it cannot be caught between the dies at the beginning of the return stroke. This knock-off is located at *F* on the machine shown in Fig. 4. The same general type is also used on the machine illustrated in Fig. 5.

### Semi-automatic Feeding Mechanisms

Most thread-rolling machines are either arranged for feeding blanks to the dies by hand or are equipped with an automatic feeding mechanism. In some cases, however, a semi-automatic feed is employed, and this type will be referred to before describing the kind which is entirely automatic in its operation. Fig. 5 illustrates how this semi-automatic feeding arrangement is applied to some of the Manville thread-rolling machines.

As explained previously, when blanks are fed to the dies entirely by hand, each blank must be placed in the feeding position. This method has proved very satisfactory, because the operator soon becomes so expert that the feeding is done almost as regularly as when some form of mechanical feeding device is employed. The hand-feeding method, however, requires the constant attention of the operator, which is not the case with the semi-automatic type. When the latter is applied to a machine, the operator, instead of inserting a blank between the dies for each stroke, simply transfers a number of blanks from the shallow pan *A*, Fig. 5, to the inclined tracks *B* which convey the blanks down to the dies. The blanks are fed down these tracks by gravity to a mechanism which automatically presents each successive one to the thread-rolling dies for every stroke of the machine, the same as when an automatic feed mechanism is used; therefore, when the machine has a semi-automatic feed it is simply necessary for the operator to keep the chute or tracks loaded with blanks. This type of feed mechanism is especially adapted for certain classes of blanks which are not readily lifted and caught by a slotted swinging plate such as is used with the automatic feed mechanism. When the heads of the blanks are comparatively large and the shanks short, or if the shanks are unusually long, difficulty may be experienced with a feed mechanism which is entirely automatic.

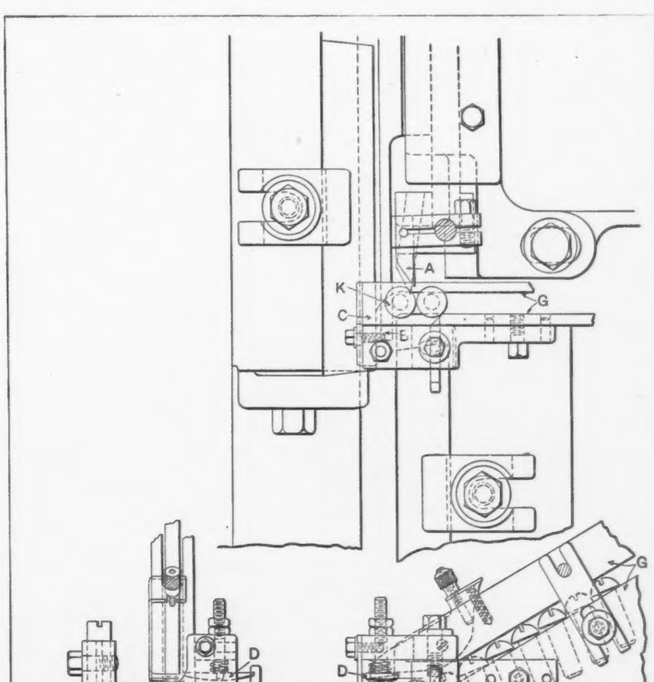



Fig. 10. Escapement or Cut-off Mechanism at Lower End of Feed Chute for feeding Blanks One at a Time to Dies

**Automatic Feeding Mechanism for Thread-rolling Machine**

Many of the thread-rolling machines now in use are equipped with an automatic feeding mechanism which is so arranged that the blanks to be threaded are transferred from a hopper to the dies entirely by mechanical means. A machine made by the Waterbury Farrel Foundry & Machine Co., equipped with an automatic feeding mechanism, is illustrated in Fig. 7. The entire automatic feed mechanism is mounted upon a hinged or pivoted member, so that it can be swung to one side, as illustrated in Fig. 9, in case it is desirable to feed the machine by hand. For instance, if only a few thousand screws or bolts of given size were required, the hand feed would doubtless be preferred to the automatic feed, because the latter requires more or less adjustment for adapting it to work of a different size.

A number of the blanks to be threaded are placed in the hopper *A*, and extending vertically through this hopper there is a blade *B*. This blade is pivoted at the inner end and it swings up and down through the mass of blanks when the machine is in operation, the swinging movement being derived from a roller *C* attached to the gear *E*. A vertical slot or opening extends along the upper edge of the blade, and this slot is a little wider than the diameter of the screw blank bodies; consequently, as the blade moves up through the mass of blanks in the hopper, some of them fall into the slot and are caught by the heads. When the blade reaches the top of its stroke, it remains stationary for a short time, and as the upper edge is inclined considerably, the blanks which were caught slide down to the lower end of the blade and then pass into the chute *D* which leads down to the dies when the mechanism is in the feeding position. The plate *F* attached to the oscillating blade or center-board of the hopper has a circular section which is concentric with the path of roller *C* and provides the dwell of the blade at the top of the stroke. The blade remains stationary long enough for all the blanks to slide down into the chute. Near the point where the blanks leave the blade, there is a rapidly revolving toothed wheel, so located and formed that any blanks which are not suspended by the heads and in the proper position are dislodged and thrown back into the hopper. In this way, the entrance to the chute is kept clear and clogging is prevented.

One of the interesting features of this mechanism is the escapement at the lower end of the chute which automatically feeds one blank at a time to the dies. At the lower end of the chute there is a V-shaped cut-off finger *A*, Fig. 10, which moves in at the proper time and separates the lowest blank *K* from the others in the chute. This cut-off finger derives its movement from a cam surface on the main slide. The blank which is separated from the others by the cut-off finger is placed in front of the push-finger *B*, which at the proper time advances it to a point where it is caught between the dies. The action of the cut-off finger is so timed that it remains in the inner position and prevents the column of blanks from descending until the push-finger is in position to serve as a stop; the cut-off finger then withdraws and the blanks descend far enough to allow the lowest one to be separated from the others as the cut-off finger again advances on the next succeeding stroke. The blank passes around a corner after leaving the cut-off finger, so that its movement is then parallel to the thread-rolling dies. While the blank passes through this parallel section of the guide plate *C*, the head is held downward upon the guide by a spring plate *D* above. This feed mechanism is so arranged that the blanks are suspended by their heads from the time they are caught by the swinging hopper blade until they are gripped between the threading dies, unless it is necessary to roll a thread close up to the head. In that case, the guide plate which holds the blank after it leaves the cut-off finger is changed. The surface of guide plate *C* is beveled and plate *F* on the opposite side is reversed, so that the blank is lowered to a point where the under side of the head is level with the upper edges of the dies. When the thread does not need to be rolled close up to the head, each blank is suspended from the head until it is pushed forward and is caught between the dies; consequently the length of the threaded part depends upon the vertical distance $x$ between the guide plate and the dies. This distance (which is very small for threading close to the head) may be varied for rolling threads of different length by adjusting the entire feed mechanism vertically. The screw for making this adjustment is located at *G*, Fig. 9.

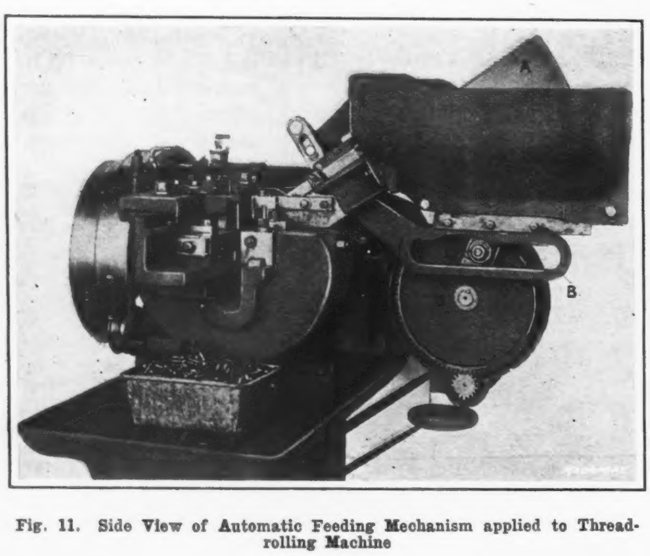


Fig. 11. Side View of Automatic Feeding Mechanism applied to Thread-rolling Machine

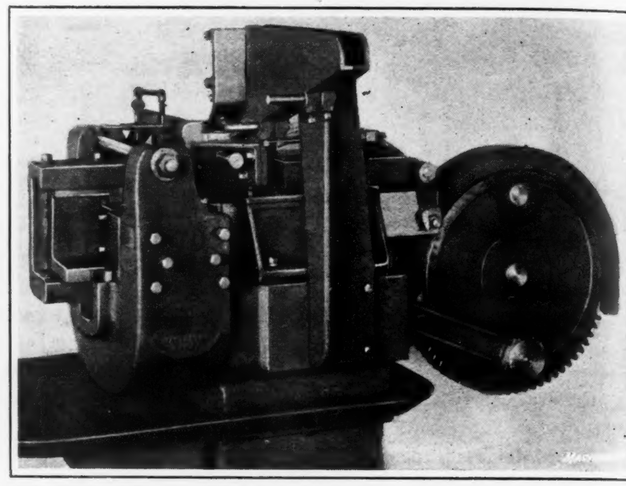


Fig. 12. Machine provided with Magazine Feeding Attachment designed for handling Studs or Headless Blanks

In adapting this mechanism for different sizes and shapes of blanks a certain amount of adjustment is necessary, as previously mentioned. In some cases it may also be necessary to alter the end of cut-off finger *A*, Fig. 10, as, for example, when the blanks have countersunk or oval heads. For instance, in the case of a countersunk head, the edge of finger *A* would be provided with a groove for engaging the blank heads, in order to prevent any tilting action. The chute *G* leading from the hopper to the dies is adjusted in accordance with the diameter of the work, and the pick-up blade in the hopper has a removable top, which can be replaced if necessary. A given width of slot can be used for a limited range of blank diameters without change. The automatic feed mechanism of a machine intended for comparatively light blanks is equipped with what is known as a vibrator. This consists of a rotating shaft carrying pins inserted in a flange and arranged to strike fixed pins and thus cause a rapid succession of light blows. The purpose of the vibrator is to prevent the blanks from sticking in the feed chute, as they sometimes tend to do when very light, and especially if covered with oil.

The automatic feeding mechanism of a thread-rolling machine made by the E. J. Manville Machine Co. is shown in Fig. 11. The slotted blade which oscillates through the center of the hopper and its operating mechanism are clearly shown in this illustration. The lower edge of this blade *A* is bolted to the swinging arm *B*, which derives its motion from the crankpin roller *C* attached to gear *D*. This blade has a positive upward and downward motion, the roller engaging a slot

formed in the arm. The blade is shown at the upper end of its stroke, the roller being in contact with the circular concentric surface of the swinging arm. This mechanism, like the one previously described, is so arranged that the descending row of blanks is held back by a cut-off device until, at the proper instant, the lowest blank is separated from the others and forced outward in front of the pusher slide, which then starts it between the stationary and moving dies. In conjunction with this feeding mechanism, there is also a simple mechanical device which automatically throws back into the hopper all blanks that are not hanging in the right position as they pass into the inclined tracks leading to the dies.

### Magazine Feeding Mechanism for Headless Blanks

The thread-rolling machine illustrated in Fig. 12 has a magazine feeding attachment which is designed for feeding automatically headless blanks that may require a screw thread on one end, both ends, or a thread extending the entire length. The blanks are placed horizontally in the magazine or hopper by the operator. At the lower end of the incline in the magazine hopper there is an agitator arranged to prevent the blanks from becoming clogged. The lower blank at the end of the incline is transferred to the dies or starting position by an oscillating segment, which, as each successive blank is transferred, changes it from a horizontal to a vertical position.

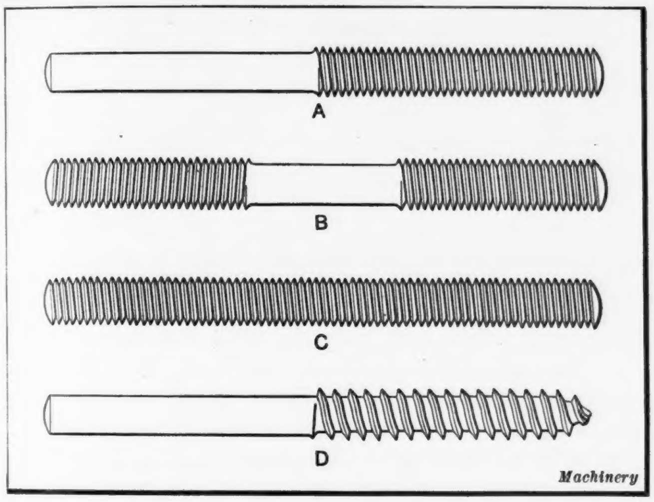



Fig. 13. Examples of Work threaded by Machine shown in Fig. 12

This segment has a notch that receives the lower blank, which is in a horizontal position when it leaves the magazine. The blank is then placed in a vertical position, after which it drops by gravity from the segment and in front of the starting slide plate. The position of the blank relative to the dies is controlled by an adjustable depth gage, and at the proper time it is pushed forward and gripped by the moving die and is then rolled through the die in the usual manner. The turning of the segment for changing the position of the blank from horizontal to vertical is effected by a spring, and the return movement is positive, being derived from a cam. This arrangement is to avoid any damage to the machine in case a blank should become lodged partly in the segment and partly in the magazine. The notch in the segment which receives the blank has a spring finger so arranged that when the segment swings the blank to a vertical position, if it should fail to drop out of the segment or drop only part way, no damage could occur to the machine or the feeding mechanism.

This design of magazine feed is adapted especially for threading parts such as are found in harvester machinery, various forms of special bolts, turnbuckle screws, skate screws, etc. One end of a piece may have a right-hand thread and the other end a left-hand thread, but whenever threads are rolled simultaneously on both ends of the blanks the diameter and pitch must be the same. A few examples showing in a general way the kind of work for which this thread-rolling machine may be used are illustrated in Fig. 13. The part shown at *A* has a thread rolled on one end only. The rod *B* has a right-hand thread on one end and a left-hand thread on the other end. The piece shown at *C* is an example of work requiring a thread the entire length of the blank, and *D* shows a lag screw thread and a gimlet type of point. When threads are to be rolled simultaneously on each end of the part and an unthreaded portion is to remain between the threaded sections, as illustrated at *B*, the dies are separated by one or more fillers, according to the length of the unthreaded part. The

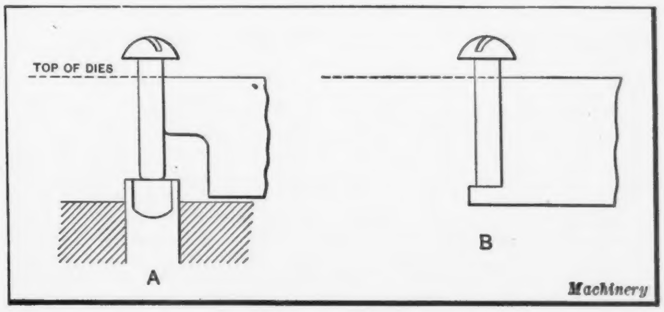



Fig. 14. Two Forms of Stops for regulating Length of Rolled Thread

special thread-rolling machine illustrated in Fig. 12, equipped with the magazine just described and extra deep dies, is made by the Waterbury Farrel Foundry & Machine Co.

### Length of Rolled Thread and Methods of Regulating

The maximum length of thread that can be rolled in any one machine depends, of course, upon the size and design of the machine. In general, the maximum length of thread is nearly equal to the full face width of the deepest die the machine is capable of using. It is not practicable to roll a thread the entire depth of the dies, as an allowance of about 1/8 inch should be made. The thread-rolling machines made by the Waterbury Farrel Foundry & Machine Co. for rolling exceptionally long threads have one or two tie-rods extending across the frame above the dies to take part of the strain when threads are being rolled. The machine illustrated in Fig. 12 is provided with one of these tie-rods. This reinforcement prevents the dies from springing apart when rolling exceptionally long threads, and insures accurate work. A tie-rod does not interfere with the operation of an automatic magazine feeding mechanism nor with feeding the machine by hand, although the work must not project above the dies far enough to strike the tie-rod.

The length of the rolled thread within the range of any one machine may be regulated in three general ways: First, by placing the end of the blank against some form of stop which is located below the top of the dies a distance equal to the length of thread to be rolled; second, by suspending the blanks for screws, bolts, etc., from the heads; and, third, by cutting away the ridges or threads on the dies down to a point from the top equal to the length of the unthreaded section. When a thread-rolling machine is fed by hand, the lower end of each blank, ordinarily, is placed against some form of stop, except when a thread is required close up to the head, in which case

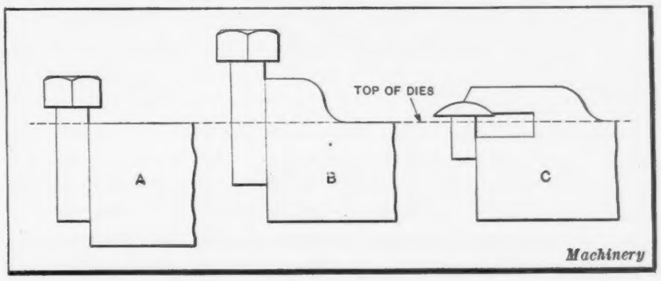



Fig. 15. Push-fingers or Starters for Thread-rolling Machines

the under side of the head serves as a stop and drops down to the level of the dies. A stop may be in the form of an adjustable depth gage, as indicated at *A*, Fig. 14, or the vertical position of the blank relative to the dies may be controlled by a projecting end or shoulder on the starter or push-finger, as illustrated at *B*. The latter has the disadvantage of not being adjustable.

With a machine of the design shown in Fig. 7, which has an automatic feed, the length of the thread is adjusted, as

previously mentioned, by simply raising or lowering the entire feed mechanism by means of a single screw. This method of regulating the length is possible because the blanks are suspended by the heads until caught between the dies, except when the lower end of the mechanism is changed for rolling a thread close up to the head, in which case the blank is, of course, pushed down to the level of the dies.

#### Shape and Location of Push-fingers or Starters

The push-finger or starter of a thread-rolling machine is usually made in the form of a rectangular plate having a vertical edge which comes into contact with the body of the blank and pushes it squarely between the dies at the proper time. A simple form is illustrated at *A*, Fig. 15. The width of this push-finger should be a little less than the space between the dies. It is essential to use a push-finger which tends to hold the blanks square or perpendicular to the line of travel of the movable die. One that is not properly formed or located relative to the blank may, by acting against one end, tilt the blank from a vertical position. If a comparatively short thread is to be rolled and the blank extends considerably above the dies, an offset push-finger may be required (see sketch *B*) to secure greater contact along the blank body.

In some cases, a plain vertical edge on the push-finger is not sufficient, and it is necessary to make a special form. An example is illustrated at *C*. In this case, the blank is very short, and, as a space is required to clear the guide plate of the automatic feed mechanism, the push-finger is made with an upper section or extension which bears against the oval head of the blank as the illustration indicates. By supporting the blank at both ends, it can be pushed forward without tilting it. The exact shape and position of these special push-fingers depends, of course, upon the length of the blank and the shape of the head.

* * *

## DESIGN OF FRICTION WHEELS

BY LUDWIG EISENKRAMER[1]

Some time ago, the writer was asked to design a concrete mixer on which friction wheels would be used to transmit motion from the driving to the driven, or drum, shaft. The requirements were as follows: The driven shaft *B*, Fig. 1, was to make 90 revolutions per minute while the driving

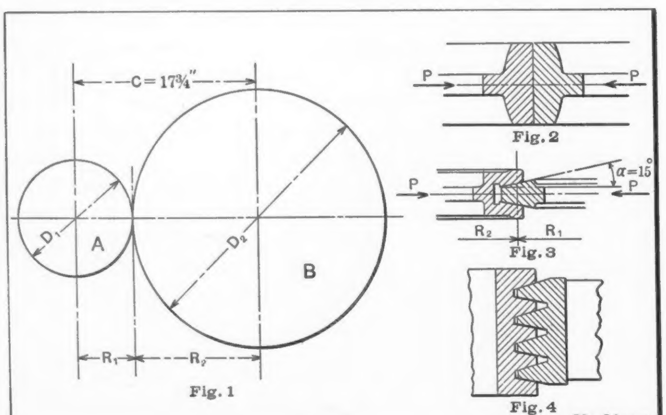



Fig. 1. Friction Wheels of a Concrete Mixer. Fig. 2. Friction Wheels with Plain Surfaces. Fig. 3. Friction Wheels with Cone Surfaces. Fig. 4. Multi-cone Friction Wheels

shaft *A* made 200; the shafts were to be 17¾ inches apart; five horsepower was to be transmitted; and the wheels were to be engaged, and then disengaged, thirty times an hour, working together for one minute and then disengaging for one minute.

The first step in designing was to determine the normal pressure *P*, in pounds, by which the wheels *A* and *B* are pressed together at the line of contact. The radius $R_1$ of the driving wheel *A* was found to be:

$$R_1 = \frac{C}{N_1 + N_2} \times N_2 = \frac{17\tfrac{3}{4}}{200 + 90} \times 90 = 5\tfrac{1}{2} \text{ inches, approx.}$$

[1] Address: 4227 Evans Ave., St. Louis, Mo.

in which $C$ = center distance of shafts;

$N_1$ = speed of driving wheel *A*;

$N_2$ = speed of driven wheel *B*.

The diameter $D_1$ of the driving wheel is, therefore, 11 inches. The radius $R_2$ of the driven wheel was found to be:

$$R_2 = \frac{C}{N_1 + N_2} \times N_1 = \frac{17\tfrac{3}{4}}{200 + 90} \times 200 = 12\tfrac{1}{4} \text{ inches.}$$

The diameter $D_2$ of the driven wheel is, therefore, 24½ inches, approximately. As the circumferential velocity $V$ of the driven wheel *B* is:

$$V = \frac{\pi \times D_2 \times N_2}{60} = \frac{\pi \times 24\tfrac{1}{2} \times 90}{60} = 115.4 \text{ inches per second,}$$

or 577 feet per minute; the tangential force $P_1$ is:

$$P_1 = \frac{\text{H.P.} \times 33{,}000}{577} = 286 \text{ pounds, approximately}$$

As both wheels are cast iron, the coefficient of friction $\mu$ may be taken as 0.125; therefore the normal pressure of the wheels *A* and *B*, when they have a straight surface, as shown in Fig. 2, is:

$$P = \frac{P_1}{\mu} = \frac{286}{0.125} = 2288 \text{ pounds}$$

But with a wheel with a cone surface, having an angle $\alpha$ of 15 degrees, as shown in Fig. 3, the normal pressure $P$ is:

$$P = P_1 \times \left( \frac{\sin \alpha + \mu \cos \alpha}{\mu} \right)$$

$$= 286 \times \left( \frac{0.2588 + 0.125 \times 0.9659}{0.125} \right) = 868 \text{ pounds}$$

This pressure, even, is so high that it would injure the bearings; so the wheel periphery was made in the form of four cones, thus reducing pressure *P* and the pressure against the bearings to one-fourth this amount, or 868 ÷ 4 = 217 pounds. Although friction wheels with a multi-cone surface cost more to manufacture than wheels with straight surfaces, the rest of the machine does not have to be as strong. While the use of friction wheels on a concrete mixer was an experiment, this design proved very satisfactory. Thirty engagements of the wheels in an hour are possible only when the machine is very rigidly constructed.

* * *

## CADMIUM FOR RUSTPROOFING

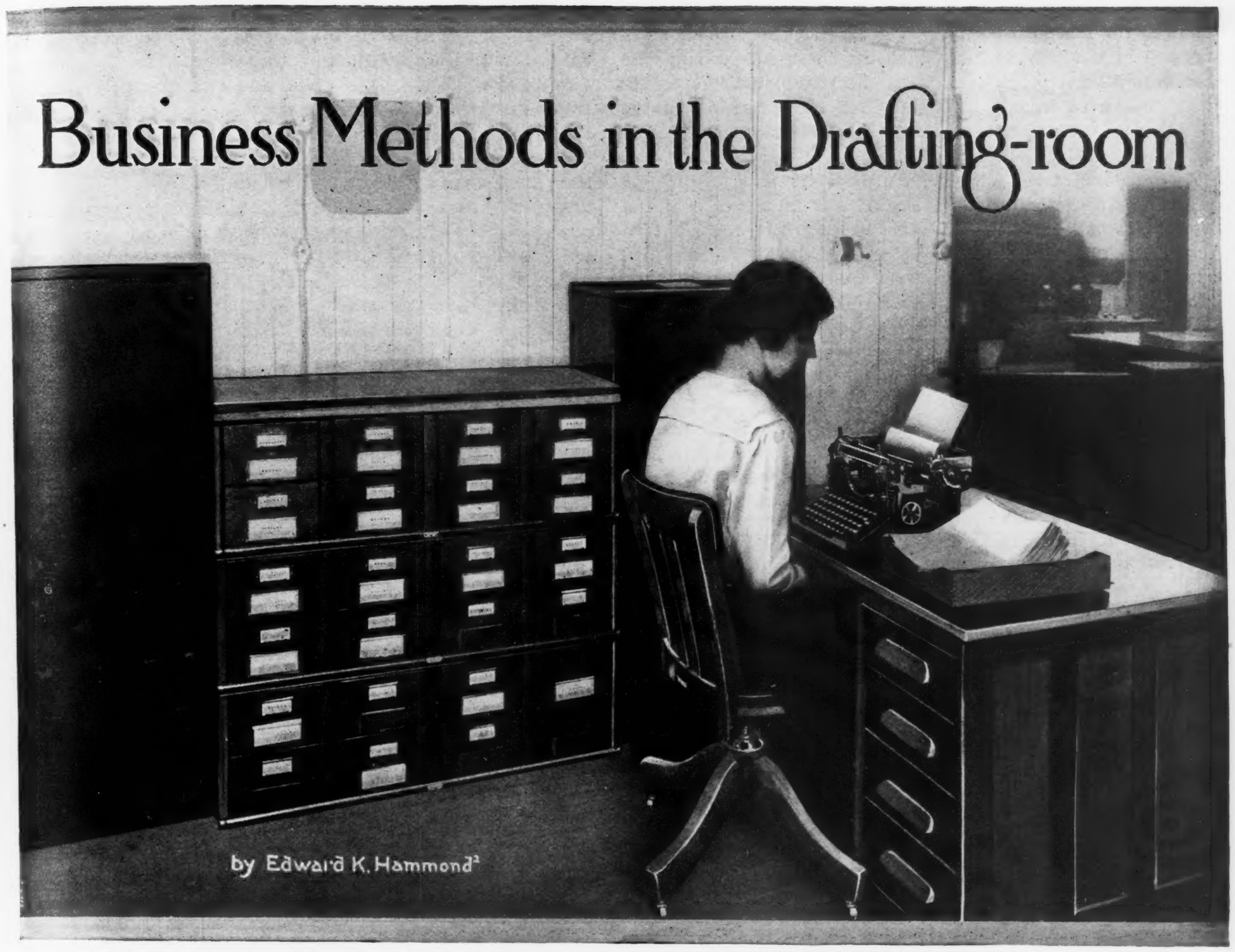
BY A. SCHLEIMER[1]

In the article entitled "Cadmium for Rustproofing" on page 633 of the March number of MACHINERY, if the word "adding" is substituted for "dissolving" in the instructions for forming the double-salt solution, the article will be strictly correct. Both cadmium hydroxide and copper oxide are insoluble in water, but they will dissolve upon the addition of cyanide of potash, in which process of solution they are changed to cadmium and copper cyanide, respectively. So that while they are themselves insoluble in water, it may be said that they are dissolved by the addition of cyanide. What is really done is to change them to cyanides, which are soluble.

The process of solution is one of changing a substance from a solid to a liquid state by means of a liquid, solid, or heat, which change is purely mechanical or physical. If sugar is added to water, it dissolves and assumes a liquid condition, from which it can be readily recovered, in its original state, by the evaporation of the water. If a piece of metallic zinc is added to water, it will not dissolve and no action takes place. But if some muriatic acid is added to the water, the zinc immediately begins to dissolve and if sufficient acid is added the zinc will entirely disappear. However, the fluid cannot be called a solution of zinc, because this would infer that it was a solution of zinc as a metal. If the fluid is evaporated, as was the sugar solution, instead of the metal zinc, a white crystalline powder will be found; this is chloride of zinc, formed by the chemical union of the metal and the acid. In other words, the zinc was changed from the metallic form to the form of chloride before it was dissolved.

[1] Address: Rutherford, N. J.

# Business Methods in the Drafting-room



by Edward K. Hammond[1]

STATIONERY for business correspondence and the maintenance of office records is made to a standard size of 8½ by 11 inches. Sheets of this size are adapted for use in standard typewriters, and they fold up to fit properly into standard-sized envelopes. In businesses engaged in building machinery or other engineering work, the usual office stationery is employed, but until recently we have not heard of the extension of this standard size for office stationery to cover tracings and blueprints made in the drafting-room. With the view of economizing in tracing cloth and paper, many drafting-rooms have been in the habit of using what is known as a "multiple system" of sheet sizes. For instance, in one case the largest sized tracings and blueprints which are required are 36 by 24 inches, and these large sheets form the basis of all smaller sized tracings and blueprints by a direct method of subdivision, smaller size sheets being 24 by 18, 18 by 12, and 12 by 9 inches. So far as the complete using up of tracing cloth and blueprint paper is concerned, such a method of cutting up large sheets is admirable; but in filing tracings and blueprints, confusion is likely to be experienced through the necessity of handling sheets of different sizes; and when mailing blueprints in connection with engineering specifications, etc., there is almost sure to be trouble because of the lack of conformity of size between the office stationery and the sheets on which blueprints are made.

In the plant of S. F. Bowser & Co., Fort Wayne, Ind., the inconvenience resulting from this lack of uniformity in the size of blueprints and office stationery led Sherwood Hinds, factory engineer of the Bowser plant, to make a study of the subject, and he finally reached the conclusion that there was no good reason why the 8½- by 11-inch standard size for sheets of business stationery could not be extended to cover requirements of the drafting-room. Blueprints of working drawings for use in machine shops are generally made on sheets of about the standard business letter paper size; for instance, in the case referred to, where a practice is made of subdividing large sheets, a size of 9 by 12 inches is frequently employed for shop drawings. On the other hand, there are a great many assembly drawings where the amount of detail is so great that the scale to which the drawing is made requires the use of a much larger sheet. After giving the matter some thought, however, it was seen that this need not represent an unsurmountable obstacle to the use of the 8½- by 11-inch business standard. For small shop drawings, blueprints 8½ by 11 inches in size are ample to meet all requirements, but in cases where larger sheets are necessary, these are made in multiples of the basic size, so that they may be folded up and mailed with letters and specifications, making a neat package which will fit into an ordinary envelope with the letter unfolded. To facilitate folding blueprints to the standard 8½- by 11-inch size, the tracings are made with index marks on them to indicate the points at which the prints should be folded.

Fig. 1 shows the lay-out for different sizes of tracings that are used and the way in which "folding lines" are provided to show how to fold the blueprint made from the tracing. It will be seen that the sheet size numbers run 1, 2, 3, etc., for sheets measuring 11 inches from top to bottom, and 12, 13, 14, etc., for sheets measuring 21¾ inches from top to bottom. For sizes designated by numbers higher than 10, the 2, 3, 4, etc., indicates the width of the drawing, while the 10's digit indicates that the height is 21¾ inches. For a drawing still larger than any of those shown in Fig. 1, the same system of numbering is used; for example, a drawing 44⅜ inches wide by 32¼ inches long would be called size No. 26, the 6 denoting the number of folds right to left and the 2 indicating that there are three folds from top to bottom.

In folding up a blueprint, the bottom is first folded under, and then, starting at the right-hand side, the print is folded inward continuously until the last fold has been made. The tracings are ruled with a slight taper at the top edge of the sheet, starting from the left-hand edge; this taper is 1/16 inch

[1]Associate Editor of MACHINERY.

per fold, although 1/4 inch is the maximum taper which is allowed for the entire length of a sheet. The top edge was tapered in this way so that, when the sheet is folded up, the corners will not project. After a sheet is folded, the corner will be located from 1/16 to 1/4 inch below the top of the outside sheet, thus allowing the folded blueprint to be turned over more easily when looking for a print in a binder.

The spacing of the folding lines for different sizes of blueprints is clearly indicated in Fig. 1, and in the case of the No. 14 size of sheet, it will be seen, reading from right to left, that these lines are spaced 8⅝, 7½, 7¼, and 7⅛ inches, respectively, while from top to bottom the spacing is 11 and 10¾ inches. The reason for having the distance between folding lines decrease by regular intervals from left to right and from top to bottom is that in folding up a blueprint the bottom of the sheet is first folded in, and then, starting at the right-hand side, the sheet is folded inward until it has been reduced to the unit size of 8½ by 11 inches. Decreasing the distances between folding lines as indicated makes the sheet fold flat, while it would be bulky if the folding lines were uniformly spaced. The reason for making the reduction between the second and third folding lines 1/4 inch and then making subsequent reductions by intervals of only 1/8 inch is to make the last fold a clean-cut, sharp fold, so that the folded-up print may be conveniently turned over like the leaf of a book.

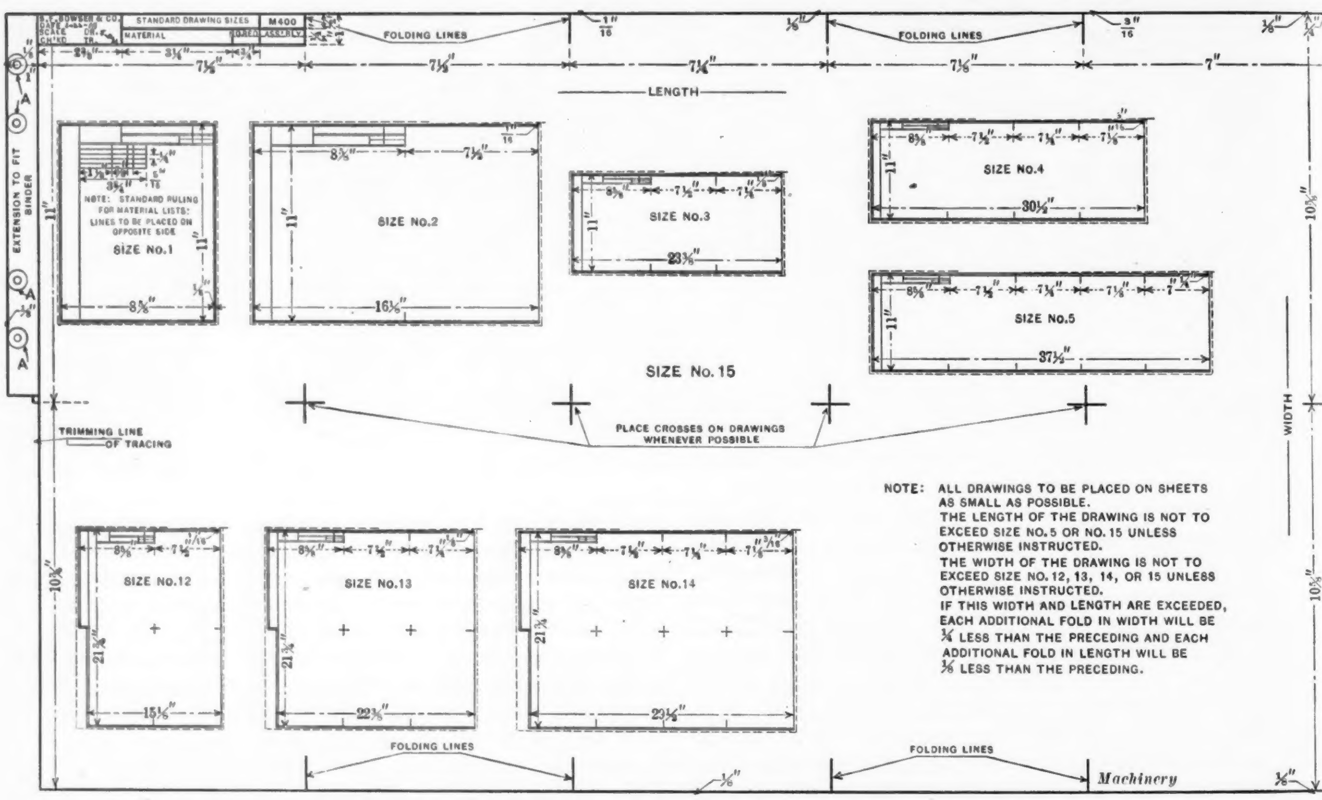



Fig. 1. Reproduction of Blueprint showing Location of Title, Provision of Extension to fit Binder, Folding Lines which indicate Points at which Sheets should be folded up, and Linen Guard Rings A used for repairing Prints when torn out of Binder

### Advantages of Standardization in Maintaining Blueprint Files

So far we have dwelt upon the extension of business stationery sizes to the drafting-room, as regards the mailing of blueprints with specifications, etc., but this does not by any means represent the only advantage resulting from the application of this system. Another important advantage is in the maintaining of blueprint files in the drafting-room, in the offices of the company's engineers, and in any other places where a complete set of blueprints is required. An explanation has already been presented of the way in which prints are folded up for mailing, but folded up in this way the prints are also made ready for binding in the standard loose-leaf binders used for maintaining various files of data written on the regular business paper. The way in which binding is effected will be most readily understood by referring to Fig. 1, which shows a complete blueprint provided with an extension to fit into the binder. Referring to this illustration, it will be seen that at the left-hand side of the upper section of the print there is an extension one inch in width, which is punched with four holes to fit the type EA-3-R loose-leaf binders made by the John S. Moore Corporation, of Rochester, N. Y. This binding edge is punched with four holes, and as a general proposition trouble is not experienced through the blueprints tearing out of the binder. Should it happen that a print is punched badly and has to be repunched, or if the blueprint is accidentally torn at the points where the binder pins pass through the holes, the blueprint does not have to be discarded. In such cases, use is made of Dennison's No. 2 gummed rings, which are pasted around the holes, thus making the blueprint even stronger than when it was new. The arrangement of these guard rings is shown at *A*.

Attention has already been called to the practice of starting at the right-hand side of the sheet and folding inward continuously. The real object of adopting this method of folding is to obtain a folded print which acts like a single leaf when mounted in one of the loose-leaf binders. Evidently by following the practice of folding inward continuously, the outer edge of the folded print is a closed fold, so that the entire print turns over in the same way that a single leaf would. Perhaps this idea will be more clearly understood after referring to Fig. 2, which shows two binders with the blueprints folded up ready for the binder to be closed, and a third binder with one large blueprint unfolded ready for use. Business office methods have been highly standardized, and there appeared to be no reason why the same standardization could not be followed in developing methods for use in the Bowser drafting-room. Consequently, when it had been decided upon as to the different sizes in which tracings were to be made in order to produce blueprints which could be folded into the standard 8½- by 11-inch size, orders were issued for sheets of tracing paper to be printed with the border line, "folding lines," and with a space ruled for insertion of the title, drawing number, etc.; in other words, these sheets were printed so that draftsmen would not spend their time in doing work by hand which could be much more economically done in the printing office.

In this connection, the arrangement of the border lines for the tracing and the provision made for cutting away the surplus paper around the edge of the blueprint are of interest. It will be seen that each side of the blueprint is ruled with a border line which is located closer to the margin than is the ordinary practice in drafting-rooms. It is the idea to have

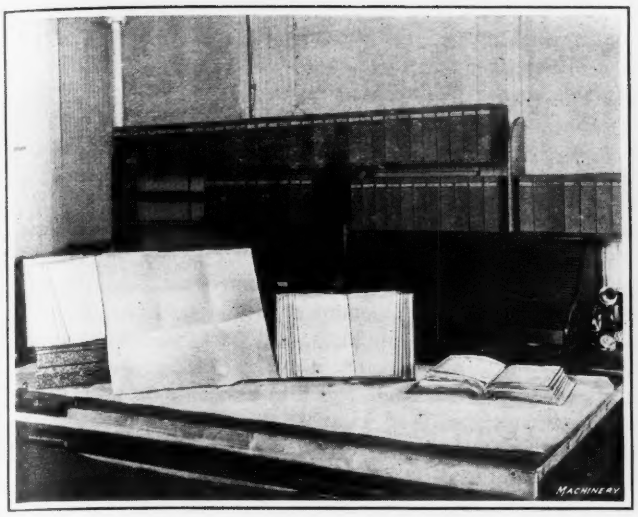



Fig. 2. Blueprint Binder with One Sheet opened out for Reference and Two Binders with Prints folded up


Fig. 3. Complete File of Blueprints arranged in Binders to which Reference may conveniently be made

this border line extended right around the extreme edge of the blueprint, and to provide for obtaining this result, each tracing is ruled off with a double border line extending around. The lines of this double border are placed 1/16 inch apart, and the reason for using a double border instead of a single line is that experience in trimming blueprints has shown it to be more simple for a man using shears to cut between two lines than it is for him to follow a single line. Hence, by cutting between these two lines, a margin line is left which extends around the edge of the blueprint, giving it a neatly finished appearance. The arrangement of the double lines between which the cut is made in trimming the edges of blueprints is indicated in Fig. 1, and the boys employed to do this work are carefully watched to see that the inside line is clearly visible all the way around the blueprint, while all of the outside line must be cut away. The dotted line shown around the outside of the double border lines in Fig. 1 indicates the manner in which the tracings are trimmed to within 1/8 inch of the outside margin line.

Particular attention is called to the position of the frame for the title, drawing number, etc., which will be seen in the upper left-hand corner of the blueprint in Fig. 1. This position, as compared with the usual practice of placing the title in the lower right-hand corner of the drawing, will seem strange until its position is compared with that of the first folding line; then it will be seen that, when the sheet is completely folded up in a binder, this title and drawing number appear on each folded sheet as successive sheets are turned over in the binder, without requiring time to be spent in unfolding the sheets, when it is required to locate a given blueprint by its drawing number. Two files of blueprints in binders are maintained in the drafting-room, one of these being arranged numerically according to the drawing numbers, while the other has the blueprints classified according to the parts which are shown. In the latter file, prints from all drawings of stuffing-boxes, valves, pump plungers, etc., are arranged together according to this classification, so that, if it is required to locate a drawing of a given part without knowing the drawing number, the task is greatly simplified by referring to this file. Figs. 3 and 7 show these two files.

### Blueprints of Standard Commercial Parts

In making out bills of material for assembly drawings, difficulty was sometimes experienced through failure of draftsmen to use the proper commercial names in specifying parts which it was their intention should be used in assembling. To correct this undesirable condition, each piece of standard commercial hardware used in assembling any Bowser product was given a drawing number. In handling this work, the catalogues of all manufacturers from whom such parts as bolts, nuts, washers, set-screws, etc., were purchased were gone over by the drafting department and lists of the proper commercial names of these parts were made with a drawing number assigned to each.

These lists were copied on the typewriter on 8½- by 11-inch sheets of tracing paper with a reversed carbon paper on the back, and these made good clear blueprints for the use of the draftsmen in making up bills of material, so that any given part could be specified by its drawing number, thus practically avoiding any chance of mistakes being made. These blue-

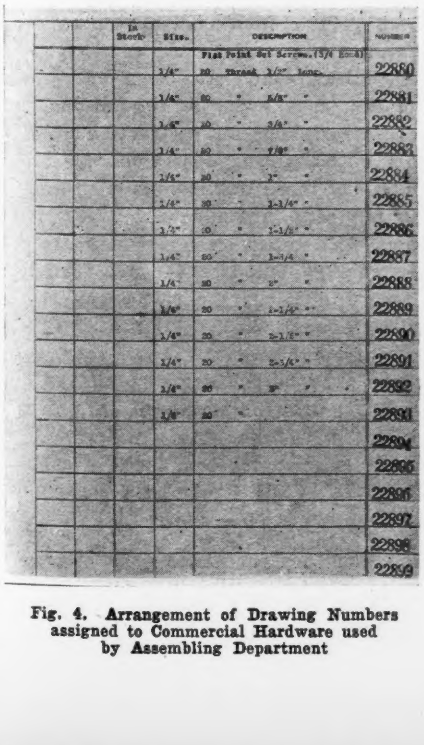



Fig. 4. Arrangement of Drawing Numbers assigned to Commercial Hardware used by Assembling Department

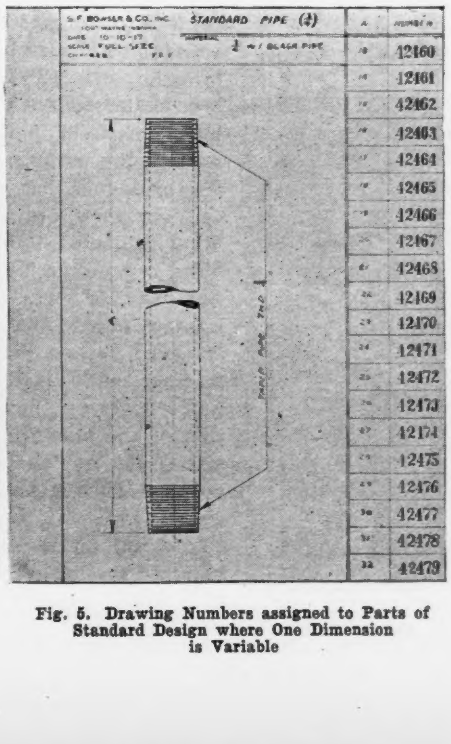



Fig. 5. Drawing Numbers assigned to Parts of Standard Design where One Dimension is Variable

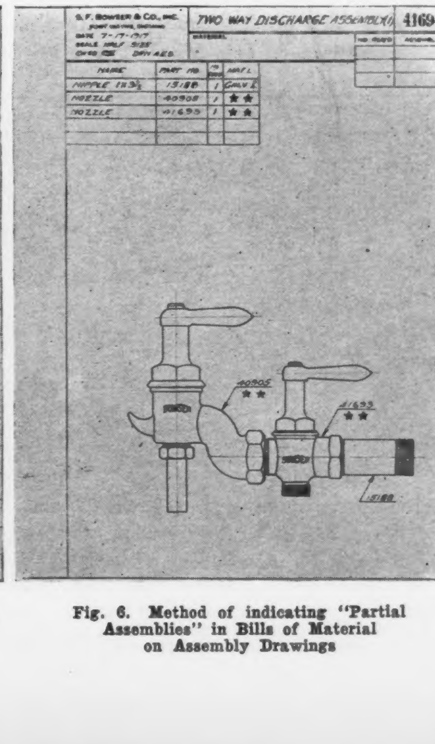



Fig. 6. Method of indicating "Partial Assemblies" in Bills of Material on Assembly Drawings

Fig. 7. File of Blueprints classified according to Parts which are shown

prints giving numbers of commercial parts are bound in binders and placed in the file of blueprints, which is arranged numerically, although there is a slight difference in the arrangement of these prints. It will be recalled from the preceding discussion that each part is given a drawing number, and attention is called to the fact that this drawing number is the same as the part number, which is believed to be a much simpler method than having different numbers for the drawing and the part. Ordinarily, there is an individual blueprint for each number, but in the case of commercial parts, blueprints are arranged with twenty numbers on each, as shown in Fig. 4, in order to economize space.

There are many parts used in the products made by S. F. Bowser & Co. which are of the same design and general dimensions, although one individual dimension may vary for different cases. For instance, use is frequently made of pieces of 3/4-inch wrought-iron pipe which are threaded at both ends and all dimensions of such pieces are the same, except the total length. In all such cases, a blueprint of the part is made with the variable dimension indicated by a letter, and pieces of each different length used are assigned different drawing numbers. These blueprints are made up with more than one drawing number to a page, with the variable dimension tabulated beside the drawing number under a letter which indicates this dimension. This practice of putting anywhere from one to twenty numbers on a sheet is not at variance with the idea that the drawing and part numbers are the same, because in such cases it is assumed that a single drawing has as many drawing numbers as the number of parts shown. For instance, Fig. 5 shows a case where there are twenty numbers, and so it is considered that this drawing has twenty drawing numbers and twenty part numbers. In cases of this kind, the numbers are always consecutive in order to adhere to this idea. There are not always twenty

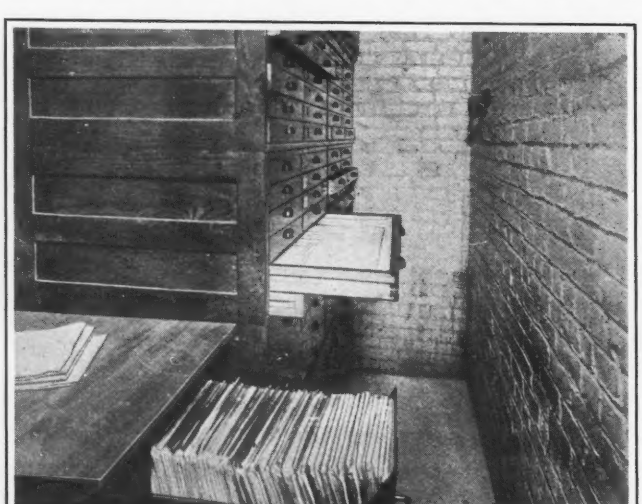


Fig. 8. Arrangement of Tracing Files in Fireproof Storage Vault

drawing numbers on a sheet; the number may run anywhere from two up to twenty, although it is the usual practice to have either five, ten, fifteen, or twenty. Here, again, a considerable economy of space is made possible.

### Concerning Use of Partial Assemblies

Many pieces are used which are termed "partial assemblies" in turning out completed Bowser products. These partial assemblies comprise two or more pieces which are made in the factory, assembled, and placed in stock ready to be drawn out upon the requisition of the assembling department. Each of these so-called "partial assemblies" is assigned a drawing number, just as if it were an individual part, and in making up bills of material on assembly drawings of complete products, the drawing number of the partial assembly is used as if it were a single piece; then, to avoid the possibility of confusion, a double star is placed in the column devoted to the specification of the material from which parts are made. In this way, the assembling department sees at once that drawing numbers with these stars placed beside them are partial assemblies, and so there is no danger of confusion. The idea of using these partial assemblies will be clearly understood by referring to Fig. 6.

### Practice Followed in Filing Tracings

For filing tracings where the system of cutting large sheets into halves, quarters, etc., is employed for making various sizes of tracings, a number of cabinets of different dimensions

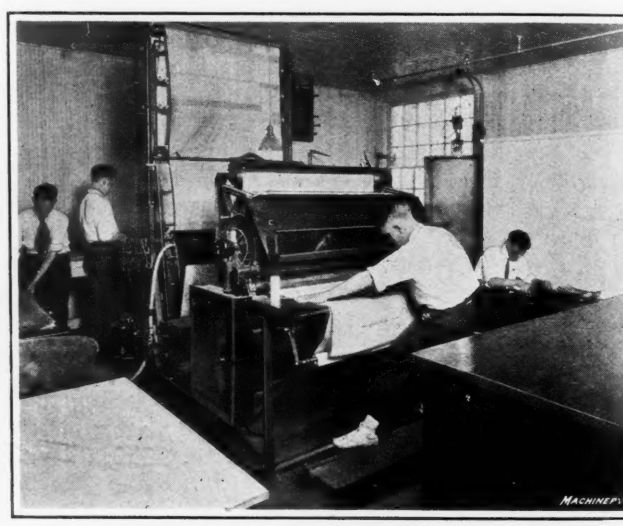


Fig. 9. Method of grouping Large and Small Tracings to secure Complete Utilization of Blueprint Paper

are required for filing sheets of various sizes, if the tracing files are to be kept in orderly fashion. The same is, of course, true of the different sized tracings required for making blueprints according to the 8½- by 11-inch system of sizes which we are now discussing, but a very satisfactory solution of the filing problem has been worked out. Attention has already been called to the fact that a majority of the tracings and blueprints used in the Bowser shops for instruction of workmen in the performance of machining operations are of the 8½- by 11-inch size, and all of these tracings are filed numerically by their drawing numbers in standard business letter filing cabinets. Cabinets with other sized drawers are provided to take the larger tracings, but, in order that their location may be readily ascertained, the file of 8½- by 11-inch tracings is made complete through the insertion of the upper left-hand section cut out from blueprints of all other sized tracings, which gives the title of the drawing and is filed numerically by the tracing's drawing number. On this section of the blueprint there is written with a red pencil the size of the tracing and its location in other sizes of cabinets required for the preservation of the larger tracings. Consequently reference to a single file at once shows the exact location of any tracing that is required. This method enables the required tracing to be located in less time than it would take if it were necessary to refer first to a card file to ascertain the location of the required tracing, and it also makes it

unnecessary to maintain such a card file. Fig. 8 shows a view in the vault where tracings are filed; the letter file for 8½- by 11-inch sheets will be seen in the foreground.

### Concerning Replacement of Obsolete Prints

In every plant engaged in building machinery or in any other line of engineering work, it frequently happens that certain minor details of an existing design are required to be changed, but quite as often as not the changes are of such a character that they may be made on the original tracings without requiring entirely new tracings to be made. In working out the new drafting-room system for the Bowser shops, provision has been made for keeping a record of all changes of this kind made on old tracings, and also of cases where entirely new tracings were found necessary. There are certain departments in the factory to which new blueprints of changed tracings must be sent to replace obsolete prints in the files in these departments; and it is the duty of the drafting-room to see that such prints are sent out just as soon as they are ready, together with a written notification of the change which has been made in the design.

At the time the new print is delivered, the obsolete print must be taken up by the messenger and returned to the drafting-room. Each department to which a new blueprint is sent receives the written notification concerning the change in the machine detail shown by the print, and as there are a considerable number of departments to receive such notifications and also because there are a number of these changes in design constantly being made, it will be obvious that the handling of this work takes considerable time. As the drafting-room system developed by Mr. Hinds for use in the plant of S. F. Bowser & Co. was worked out with the idea of securing increased efficiency through the use of modern business methods, it was fairly obvious that this work of preparing notifications for the different departments to which blueprints are sent should be handled by a stenographer in order to enable the work to be done as expeditiously as possible.

A card file is kept on 5- by 8-inch cards, which constitutes a complete record of all blueprints that are sent out to the shop, and of all changes in design that are made on tracings. This card file refers not only to prints of parts which go into the latest Bowser products, but also the parts that have been declared obsolete as a result of certain changes in design. There is a separate card in the file for each drawing, and on the reverse side of the card shown in Fig. 10 spaces are provided for recording the sending out of blueprints and the return of obsolete prints from each department to which new prints are sent. This guards against any department keeping obsolete prints in its files and making parts from such prints through mistake. When the print represented by a given card in the file is declared obsolete, a small star is stamped in the upper right-hand corner of this card and a new card is made out for the print in question. Each card is marked in its upper right-hand corner with the drawing number of the part shown by the blueprint, and it will be apparent that there may be several cards of the same number, each having the star stamped in the corner with the exception of the last card of the given blueprint number, which represents the blueprint that shows the part in its latest form.

On these cards there is a ruled space on which is typewritten a statement of the changes made in the design shown by the print; and each time a change is made on a design, requiring a new card to be made out to record this change, the card is marked with the number of changes that have been made in the design of the part shown by that blueprint. These cards are blocked up in sets of one card for the drafting-room record file and one paper sheet for each department which must receive a new blueprint and notification of the changes in design of the part shown by the print. There is also one sheet of paper for the stenographer's use in taking dictation from the chief draftsman concerning the changes made in the design, and this sheet of paper is ruled with lines like the ordinary stenographer's notebook, so that the usual positions above and below the line may be used in writing the notations in shorthand. After taking dictation concerning the changes in design in each blueprint, the stenographer tears off from the pad the top sheet on which the stenographic notes were made and all sheets on which notifications to department heads will be typewritten, together with the drafting-room record card on which a typewritten statement of the change in the blueprint will be recorded. Tearing off the complete set of sheets is an easy matter, because the girl simply runs her thumb over the edge of the pad and catches the card, which is torn off with the paper sheets that are above the card. Fig. 7 shows the record card file and a set of new blueprints for which the stenographer has made out notification slips and clipped them onto the prints ready for delivery to the factory department.

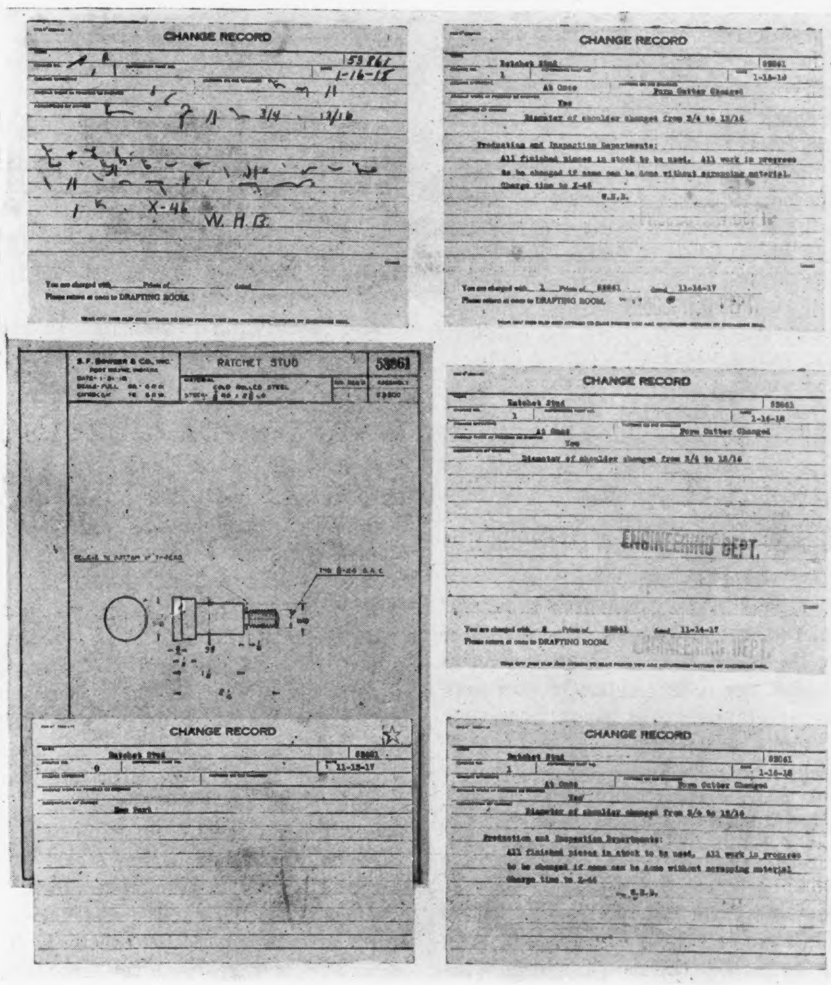



Fig. 10. Group of Change Record Cards showing Stenographer's Notes, Notifications sent to Production and Engineering Departments, Change Record Cards of Original and Corrected Blueprints and Blueprint No. 53861

Carbon paper is placed between each of the lower sheets so that all of the notification sheets and the drafting-room record card may be slipped into the typewriter and written at one time. At the bottom of each of the notification sheets sent out to the factory with new blueprints, there is a slip separated from the main sheet by a perforated line. When the new print is delivered to the department, the old print is taken out of the file in that department, and a receipt signed for the new print on the slip at the bottom of the notification sheet. This receipt is then torn off the main sheet and clipped

onto the obsolete print, so that both may be returned to the drafting-room office. A record of the delivery of the new print and return of the old one is then made on cards in the drafting-room file, and the old print and receipt are destroyed. The double entry on the back of a drafting-room record card serves to indicate that the card refers to an obsolete print, thus serving as a check on the small star stamped in the upper right-hand corner to indicate the same thing.

### Points Observed in Making Blueprints

Blueprinting is done on one of the continuous blueprinting and drying machines built by the Pease Mfg. Co., of Chicago, Ill., and in making blueprints, care is taken to select tracings of such sizes that the blueprint paper will be used up as completely as possible. In connection with Fig. 1, an explanation was given of the different combinations of the 8½- by 11-inch units to form larger blueprints and tracings of the required sizes. This arrangement provides for the use of tracing paper, tracing cloth, and blueprint paper in rolls, either 36, 42, or 48 inches in width, with practically no waste. This economy is due to the fact that there is always a preponderance of 8½- by 11-inch tracings, making it possible to use these small-size tracings to fill in the space on the blueprint paper at the side of larger tracings. The way in which different sizes of tracings are matched up on the blueprinting paper in order to avoid waste will be appreciated after referring to Fig. 9, where it will be seen that the printed area going over the drying section of the machine covers practically the entire surface of the blueprint paper. Both tracing paper and tracing cloth are used in the drafting-room, and by a careful selection of grades of paper and cloth which are equally transparent, practically no difference can be seen between blueprints made from tracings on cloth and those made from paper when they are run through the machine together and so receive the same exposure.

* * *

## METRIC SYSTEM IN WATCH INDUSTRY

BY F. A. HALSEY[1]

Referring to the article "Metric System in Watch Industry" by W. H. Dunbrack published in MACHINERY for March, I quote as follows: "But adopting the metric system as it is used in the watch industry in Waltham, Elgin, Lancaster," etc. I have before me a letter from the superintendent of the Elgin National Watch Co. from which I quote as follows:

> So far as I know, all watch manufacturers in this country with the exception of the Waltham and the Ingersoll companies use the English system of measures.
>
> Watch case making is very highly developed as a separate industry. It uses neither the English nor metric system, but the old French system.

The use of the metric system at the Ingersoll works is due to the fact that those works were originally fitted out by men from the Waltham works who carried the metric system with them, but beyond this, the influence of the Waltham works has not gone.

A recent extended investigation from this office has disclosed five industries in which the metric system was really adopted—not merely introduced—at their original foundation. These industries are watches (the Waltham Works), card indexing and filing systems (Library Bureau), magnetos (the Ericsson Mfg. Co.), chemical manufacturing (the Solvay Process Co.), and steam boiler injectors (William Sellers & Co.). Of these five industries, the system, after trial, has been abandoned for mechanical purposes in three cases. In the two remaining cases, the example of the pioneers has not been followed by their competitors, and in one of them (William Sellers & Co.) the system is unreservedly condemned, although its use is continued as a lesser evil than the effort and cost of getting rid of it. They have had a longer experience with it than any other American manufacturer, this experience dating from about 1860.

It will be recognized that the most favorable conditions possible for the adoption of the metric system are those existing at the foundation of an industry; since then no change is involved. The cost due to scrapping tools, jigs, gages, etc., of which we have heard so much, is then absent, the chief difficulty to be confronted being the psychological one of learning to think in the system. Nevertheless, we find the above history of these five real and serious attempts to adopt the system under these favorable conditions. It seems to me entirely clear that if the metric system possessed the advantages claimed for it, or, indeed, any advantage, the above condition of things could not be. The favorite slogan of the metric party at the present time is: "It is better, and we want the best," and it is now for them to explain why, on trial, these advantages did not appear.

A comical element is injected into the subject by the fact that twenty years ago the Library Bureau was considered the star example of the progress of the metric system. I have in my office a transcript of a statement made by the then president of the Library Bureau before the House of Representatives Committee on Coinage, Weights and Measures a dozen years ago in which the system is extolled to the skies, and especially the workmen are represented as taking to it like ducks to water. The Library Bureau now write:

> Our draftsmen and mechanics failed to make any attempt to familiarize themselves with the metric system, but simply translated the metric dimensions into English inches or fractions thereof, and worked accordingly. I do recall, however, having known one man connected with the Library Bureau in former days who was inclined to brag that he had mastered the metric system sufficiently so that he could actually think in it as well as he could in feet and inches, but I take it that his was a very rare case.

The Library Bureau abandoned the system after giving it a trial of more than thirty years' duration.

[1] Commissioner, American Institute of Weights and Measures, 20 Vesey St., New York City.

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## WARNING—DANGEROUS ETCHING FLUID

The etching fluid formed by mixing four ounces of pyroligneous acid, one ounce of alcohol, and one ounce of nitric acid, which formula was contributed to and published in MACHINERY some years ago and republished in MACHINERY'S book of "Shop Kinks," though an active etching agent, is dangerous to mix, and therefore should not be used. Nitric acid is one of the most easily decomposed acids. It is also one of the most powerful oxidizing agents known; in fact, it is so powerful that should it come into contact with organic matter, such as paper, straw, wood, turpentine, oil, etc., it will invariably cause combustion. Alcohol is an organic body, and, at ordinary temperatures, the addition of nitric acid will produce a violent reaction; if the heat is above normal, this reaction will tend toward an explosion. Combining alcohol and nitric acid produces nitrous ether, which is a very light, volatile, and highly inflammable vapor. Pyroligneous acid is a product of the destructive distillation of wood—the source of acetic acid, wood alcohol, acetone, etc. Even if the pyroligneous acid is mixed with the alcohol and the mixture is cooled before the nitric acid is added, the etching fluid will retain its dangerous properties. The dilution will retard the speed of the reaction, but will not prevent it. The gas will form just the same, though slowly, and when the pressure exceeds the strength of the retainer, an explosion will result, together with fire if it is near a flame or spark. Besides, fire may be caused spontaneously. Hence, the mixture should not be used. The formula was contributed to MACHINERY'S columns by a contributor who apparently had not made use of the etching fluid.

* * *

As alloys of iron with boron are so hard that they can scarcely be ground with an emery wheel, it has been suggested that boron be used for casehardening. Such alloys will be especially valuable for machine parts subject to great wear. A further advantage of these alloys is that they do not need special heat-treatment, such as the annealing process required by articles casehardened by carbon. The cementation proceeds more quickly and easily with powdered ferro-boron than with amorphous boron, and a microscopic examination will show that the casehardened part of the specimen consists of compact boric pearlite with a twin crystal structure.

## INVENTIONS AND INVENTORS

BY COLE NEWMAN

The writer has spent his life among mechanics, designers, and scientific men and owns a few patents; he therefore knows whereof he speaks when he says that the way of the inventor is thorny. On the one side, the hand of the law is against him, on the other, the hand of finance. Whenever clever ideas and inventions have been incidentally mentioned by mechanics, the writer has usually asked: "Why don't you use this in your business?" "Why don't you interview your employers about it?" or, "Why don't you patent it and try to do something with it?" But the average reply has been: "What's the use? It would only benefit somebody else, who would not share the returns with me."

When a human being conceives an idea, his greatest pleasure is to put this idea into material form. It is his pet; employers, however, generally take the stand that they are entitled to the inventions of their employes, and that, even if the employe has developed the invention in his own home, it should be turned over to the employer. One manufacturer of cash registers told the writer that he encouraged inventions in his factory and amply rewarded every creator of a useful idea. A few questions developed the fact that this reward ran from $5 to $150, although some of the inventions had netted the manufacturer hundreds of thousands of dollars. During a conversation outside of the plant, one of the employes revealed a certain brilliant idea; but when told that the employers would be very glad to hear of this, the employe replied: "Nothing doing! I have sold this invention for $5000 and am leaving the company next week; the company would probably give me $25 for it."

### Attitude of Large Corporations

When the average corporation learns that a patent has been granted for something which may be of use to it, the first step is to learn how much money the inventor has back of him and what is his ability to fight. The next step is to approach the inventor with a "take it or leave it" air and offer him a few hundred dollars. If the man refuses and the corporation really desires the patent, the patent may be infringed and the man drawn into litigation. Inventors are considered by business men to be fools as far as commercial matters are concerned; they are not, as a rule, men of business experience, but rather specialists in some particular line. For this reason their imagination is likely to be highly developed along one line of thought. They are often enthusiastic dreamers, very imaginative, sensitive, suspicious, and reclusive.

A few business men have given their support to an inventor or a man able to conduct research, with great profit to themselves as well as to the inventor. A manufacturer of insulators in the United States built his entire fortune around the genius of a man who was able to conduct scientific research, but who was temperamentally unable to take care of himself in matters of common sense and finance. One large electrical corporation is dominated by the inventive genius of its chief engineer to whom money means so little that he has declined further increases of salary.

Every industry in the United States is founded on the work of an inventor; but the writer challenges the majority of firms in this country to prove that the original inventor of the product they are marketing was properly and adequately rewarded. Generally, a valuable patent is synonymous to a lawsuit. An article can hardly be considered as properly patented until its merits have been passed upon by the United States Supreme Court, which shows that a patent is potentially a lawsuit.

### Valuable Inventions that are Unavailable

The writer knows of inventions that will probably die with their owners, because of the impossibility of the original inventor making any money out of his idea. One invention is a sight for large guns to be used on battleships. This sight is so arranged that the officer keeps a light telescope pointed at the target and it is impossible for the gun to be fired unless it is absolutely parallel with the telescope, with corrections, of course, for windage, etc. When tried out in connection with a small rifle at distances of even 1000 yards, 100 per cent of hits was recorded. This inventor's business troubles were so great that he destroyed the entire apparatus.

Another invention is a periscope that shows the entire horizon, and not only a small section of it. This periscope depends on a device similar to a moving picture whereby a little motor reflects successively all points of the landscape in such rapid succession that it appears to be one continuous picture. This inventor, also, has taken apart his apparatus because of attempts made to make use of his idea without compensating him.

A third invention was an apparatus that measured the depth of water underneath a ship by the principle of reflected sound or echo. The writer saw this apparatus in action and was amazed at the results. A ship's officer, by pressing a button, could see the depth of the ocean at any time on a differential scale, in the form of a spot of light. The details of this instrument were explained to the writer, and they are quite simple when once understood, but it is doubtful if they could be duplicated by anyone but a mathematical expert in physics. There had been so many attempts to steal this idea and the people approached had tried so hard to keep the lion's share for themselves, that the inventor abandoned the whole proposition.

### Need of Greater Protection to Inventors

None of these inventors patented their inventions, because the patent gives absolutely no protection (unless there is capital behind it), while the patent laws require that the inventors must reveal their invention to the public. The inventor is thrown entirely upon the mercy of the business man. Royalties on inventions are largely a myth of dollar-and-a-half novels. Such royalties as are actually received by inventors are hardly worth mentioning, and those who receive large royalties are very few in number. A large number of inventors lose the fruits of their work, and many ideas are appropriated without compensation. The manufacturer wants new ideas, improvements, increased production, etc., but he does little to encourage the creative type of mind. He ignores the fact that the inventor *must* be a type of man entirely different from him. Ideas for improvements must come from men with broad mechanical and scientific vision, who are encouraged to do the necessary research work, and this encouragement must come from the manufacturer.

* * *

## GERMANY WANTS TO KEEP ORE FIELDS

At a recent meeting of the Union of German Iron and Steel Industries, a resolution was passed, according to *Engineering*, to the effect that it was necessary for Germany to retain possession of the iron ore deposits in northern France and to secure a sufficient supply of Russian manganese and iron ores. Before the war, 50 per cent of the iron ore necessary for German industries had to be imported, and, furthermore, in the course of forty or fifty years Germany's present known iron ore deposits would be about exhausted. Hence, it was thought quite proper that France should give up to Germany such parts of that country as contain the quantities of iron ore required for Germany. It was also stated at the meeting that Russia was in a similar position. Polish deposits could supply iron ore to the upper Silesian iron works and Swedish iron ore would also be of importance in the future. It was also mentioned that it would be necessary for the German iron works to secure their share of the extensive and valuable ore deposits in Brazil. It was emphasized that the supply of iron ore and manganese ore should be kept in the foreground at the peace negotiations, for on this, it was said, hung the continued existence of the German industry, the German state, and the German people. Probably it matters little whether other nations have any ore supplies so long as the German requirements are filled.

* * *

In England, where illuminating gas is used as motive power for motor busses, it has been demonstrated that 250 cubic feet of gas is equivalent to one gallon of gasoline.

# SENSITIVE DRILLING MACHINE SPINDLE CONSTRUCTION

## DEVELOPMENT OF HIGH-SPEED DRILLING MACHINE SPINDLES AND IMPORTANT FEATURES OF THEIR DESIGN

BY CHARLES E. BERNITT [1]

DURING the period of introduction of high-speed steel when the majority of machine tools were redesigned and developed to increase the production, ease of operation, and the speeds and feeds, little attention seems to have been given to one of the most important machine tools in the shop—the sensitive drilling machine. It is safe to say that nine out of ten machine shops have one or more sensitive drilling machines in operation, and in numerous manufacturing plants the high-speed spindles may be numbered in the hundreds. Yet for a score or more of years the possibilities of the sensitive drilling machine were not realized, the design of the machine was virtually unchanged, and each new machine brought out was practically a duplicate of its predecessor. Today the sensitive drilling machine is built in fifteen different types and sizes by one maker alone, with from one to eight spindles. The spindle speeds recommended range from 150 to 12,000 revolutions per minute, and no matter what the requirements are—whether for drilling 0.0135-inch holes (No. 80 drill size) in brass or aluminum, or 1-inch holes in mild steel—there is a sensitive drilling machine adapted for the work. This development was brought about in a comparatively few years, and is the result of a natural demand for a machine of greater efficiency to keep pace with increased quantity production, and the need for correct speeds when drilling small holes in interchangeable parts such as are found in typewriters, adding machines, automobiles, rifles, and similar products, where a fraction of a second per drilled hole is an item of no small importance. The paramount necessity of meeting these and other requirements has brought the sensitive drilling machine to a point where it must be seriously considered when estimating drilled hole output.

While different manufacturers encountered the same problems, they naturally followed different courses in seeking their solution. Countless forms of columns or housings, various methods of driving from the countershaft to the spindle, different types of tables and elevating devices, and sundry ways of varying the belt tension and of obtaining speed changes, were adopted, redesigned, and perfected. But it is the spindle and its construction to which this article is confined, because the spindle, its bearings and their mounting, and the design of the spindle pulley required the most attention in developing the modern sensitive drilling machine. Possibly a stronger reinforcing of the column against vibration and a careful selection of driving belts were contributing factors to its ultimate success. It may be well to note here that it is not the purpose of this article to describe all the existing forms of spindle design, but rather to relate the experiences of one manufacturer in improving and developing the construction to its present degree of efficiency. However, the spindle arrangements illustrated and described may serve very well as an index to general practice.

[1] Address: 2735 Faber Ave., Westwood, Cincinnati, Ohio

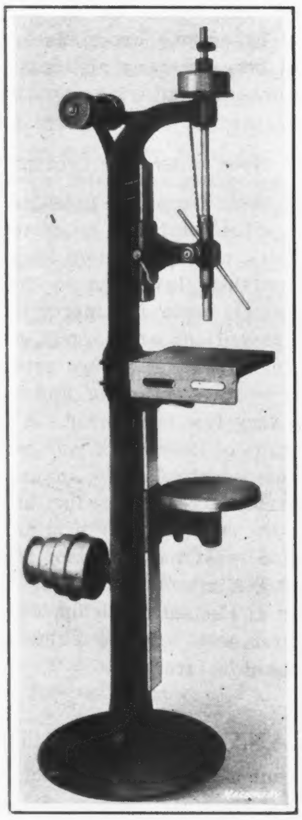

Fig. 1. Sensitive Drilling Machine with Old Type of Spindle

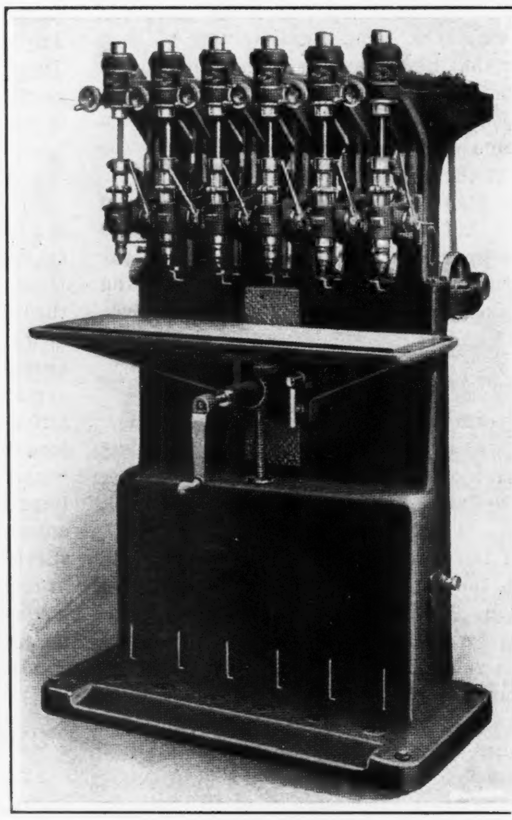

Fig. 2. Modern Type of High-speed Ball-bearing Sensitive Drilling Machine having Spindle Construction illustrated at B, Fig. 6

### Old Design of Sensitive Drilling Machine Spindle

Fig. 1 is an illustration of what is commonly known as a sensitive drilling machine. Without doubt this is a sensitive drilling machine; there is still a wide field of usefulness for a machine of this type and at the present time a dozen or more manufacturers are building a machine that is similar to, or that varies only slightly from, the original design. But, as the machine shown in Fig. 1 was designed sometime in the eighties, it furnishes an excellent example of the old type of spindle construction. A cross-section of the spindle, the spindle quill or sleeve, the head, and the pulley mounted on the top of the column is shown at *A*, Fig. 4. The entire machine, including the spindle, has plain bearings, with a resultant loss of power due to friction. Additional power is consumed at the point where the thrust of the drill is taken by a fiber washer. High speeds, of course, are impracticable, and a machine with this design of spindle is seldom recommended for drill speeds exceeding 500 or 600 revolutions per minute.

The drive is transmitted to the spindle by means of screw-key *c* through the pulley and bushing *d*. This sort of key is obviously a poor design, as it affords very little driving surface on the spindle keyway. It has a tendency to open out the keyway, especially when drilling a great many holes with the table and head in one position, so that the key bears continually on a short length of the sliding spindle. Some makers of the more recent models of this machine use a longer square key in place of the screw. The bushing *d* is inserted for machining purposes, to give the pulley a straight bore. In some cases the pulley is bored to the size of the spindle and then counterbored to fit the pulley sleeve. Very little can be said in favor of the stop-collar *e* on the upper part of the spindle except that it is the simplest design possible and is most easily attached. It is located too high up to be conveniently adjusted, and the operator has difficulty in setting it in conjunction with the graduations on the spindle quill below. The revolving screw head is objectionable, besides necessitating the use of a wrench or screwdriver for tightening. A sensitive drilling machine should require no tools ex-

cept those incorporated directly in the machine. This statement, of course, excludes the drift key, which is indispensable and is usually attached to the column or table by means of a chain. An examination of the repair list of this machine for some years back reveals the fact that, of the details shown at *A*, the spindle sleeve *f* required the most frequent replacement due to wear on the feed rack, which was cut directly in the cast-iron sleeve.

### Preliminary Design of Spindle for High Speeds

One of the first attempts to evolve a spindle construction for high speeds is shown at *B*, Fig. 4. The natural tendency was to use ball bearings. Exhaustive tests conducted with sensitive drilling machines of both plain and ball bearing types have proved conclusively that the loss of power in friction on the latter type of machine is only one-fourth to one-fifth that of the former, with a resultant increase in efficiency of about 200 per cent. The bearings shown are of the four-point contact design and are known in shop parlance as the "home-made" type, which means, of course, that they are made in the shop where the machine itself was built. There are several other improvements to be noted in this design. One of them is the steel feed rack, which is inserted in the sleeve between shoulders *h* and further secured by screws *j*. The stop-collar *e* is placed on the spindle sleeve closer to the operator than the previous type. It can be set directly to the graduations on the sleeve for the desired depth of hole, and is quickly clamped in position by means of lever *k*. A ball thrust bearing at the bottom of the sleeve and a fiber washer at the top are noteworthy additions. It is needless to say that most of the repairs were occasioned by the wearing of the balls and ball races in the pulley.

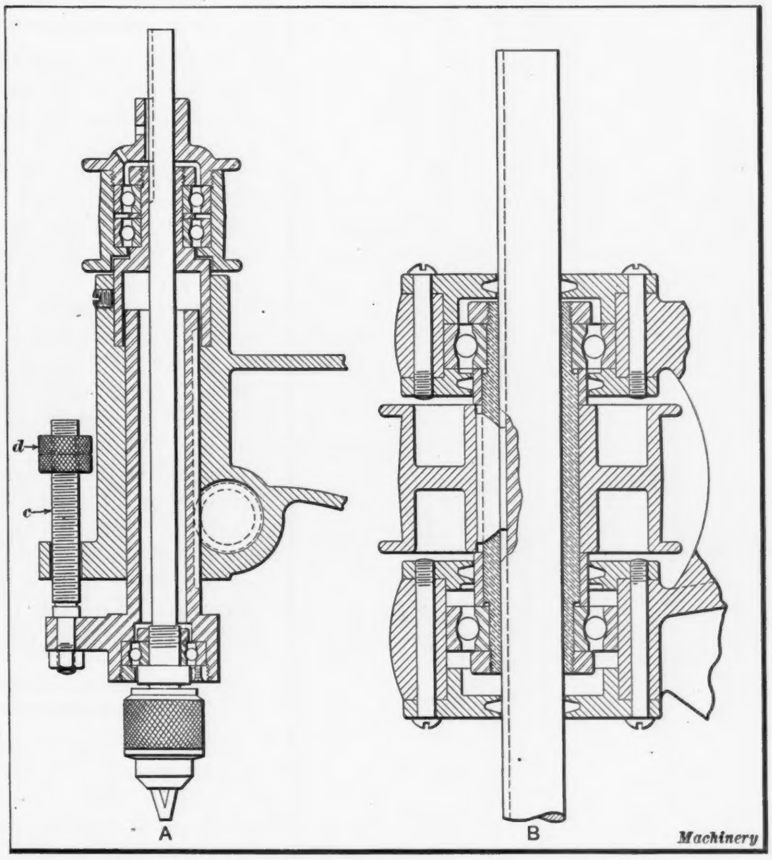


Fig. 3. (A) Spindle which proved Successful at Speeds up to 5000 R.P.M. (B) Pulley located between Bearings

Although the type of ball bearing previously referred to is now being used extensively on some sensitive drilling machines, nevertheless on many high-speed machines this bearing was discarded after a few years and the commercial type of radial bearing was adopted in its stead. Manufacturers advance many reasons why this was done. In the first place the commercial grooved radial bearing has a capacity for much higher speeds than the other type. It comes to the user completely assembled, adapts itself readily to mounting and requires no adjustments. No matter how thoroughly a machine tool builder may "rig up" in the beginning for the manufacture of his own bearings, it is not probable that he can achieve the same accurate results as those who devote their entire time and attention to the making of ball bearings alone. The manufacture of bearings is conceded to be an industry in itself, as attested by the fact that automobile builders—probably the largest users of ball bearings—almost without exception have adopted the commercial types of thrust and radial bearings. So many elements enter into the making of this product that it is admittedly beyond the scope of the machine builder to turn out a bearing of the necessary degree of precision and also make it at a profit without seriously interfering with his regular line of work.

### Spindle for Speeds up to 2000 Revolutions per Minute

A relatively modern spindle construction is shown at *A*, Fig. 5, and while this design is gradually giving way to a still more recent one, it is an excellent arrangement for a general manufacturing machine. The design permits of efficient drilling speeds up to 2000 revolutions per minute, which affords a sufficiently wide range to meet ordinary requirements. A good film of oil in the sleeve bearing and the ball thrust at the top and bottom assure a cool-running spindle.

Thus far we have seen developments in the production of a dependable machine for general shop use, with ample range to satisfy modern demands but the problem of really high speeds requires greater refinements of construction. In drilling brass as it should be drilled with high-speed drills, at 300 feet per minute, the smallest hole that can be drilled at 2000 revolutions per minute is 9/16 inch; and even in mild steel, with a surface speed of 120 feet per minute, the smallest hole is about 1/4 inch. These cutting speeds are maintained by many production managers, and under favorable circumstances are often exceeded. It is not difficult to recall numerous industries, such as the manufacture of adding machines, electrical appliances, timing fuses, etc., where the majority of drilled holes are below 1/4 inch in diameter and where a large number may be found among the eighty different drill gage sizes. In work of this kind, where parts are made in large quantities, a slight saving of time in drilling each hole augments the output considerably and is productive of enormous results in the aggregate. So it is evident that the ultimate aim of the designer must necessarily be a machine that is capable of running at speeds heretofore unheard of in a manufacturing drilling machine; and that these speeds must be maintained without undue heating of the bearings; without constant belt wear or slippage due to high speeds; and, finally, without serious vibration or noise, and with the simplest construction possible.

### Spindle Supported by Ball Bearing and without a Plain Bearing in Sleeve

The first step toward the construction of a machine for extremely high speeds is shown at *B*, Fig. 5. This design is intended to eliminate the sliding friction in the spindle sleeve bearing. As this was the only plain bearing in an otherwise ball bearing design, it naturally limited the speed capacity of the remainder of the construction. The pulley arrangement is the same as shown at *A*. A double-row annular bearing has its inner race clamped to the spindle and its outer race *l* held securely in the bottom of the sleeve. The spindle does not touch the sleeve at any point. The collar *k* is provided as a dust-cap and revolves with the spindle. This design was very short-lived, both because it failed to fulfill its promise of extremely high speeds and because for slower speeds and heavier drilling the sleeve construction shown at *A* is vastly superior. The distance between the bearing *l* at the bottom of the sleeve and the point *m* where the spindle enters the pulley bushing, was great enough to cause a "whipping" of the spindle mid-

way between these two points. This whipping action, in turn, as the speeds increased, culminated in a vibration of the whole machine. However, the design served the purpose of emphasizing the need of strengthening the entire machine from base to pulley.

The general idea incorporated in the design shown at *B*, Fig. 5, is applied to the spindle illustrated at *A*, Fig. 3, which is for a small bench type of drilling machine. This machine has no sliding head, adjustments for different heights of work being obtained by raising or lowering the table. As the spindle has a comparatively short sleeve travel, it has proved a complete success at speeds as high as 5000 revolutions per minute, notwithstanding that on the larger machine (of the type having an adjustable head and longer spindle feed) this design was a pronounced failure. The depth gage or stop-

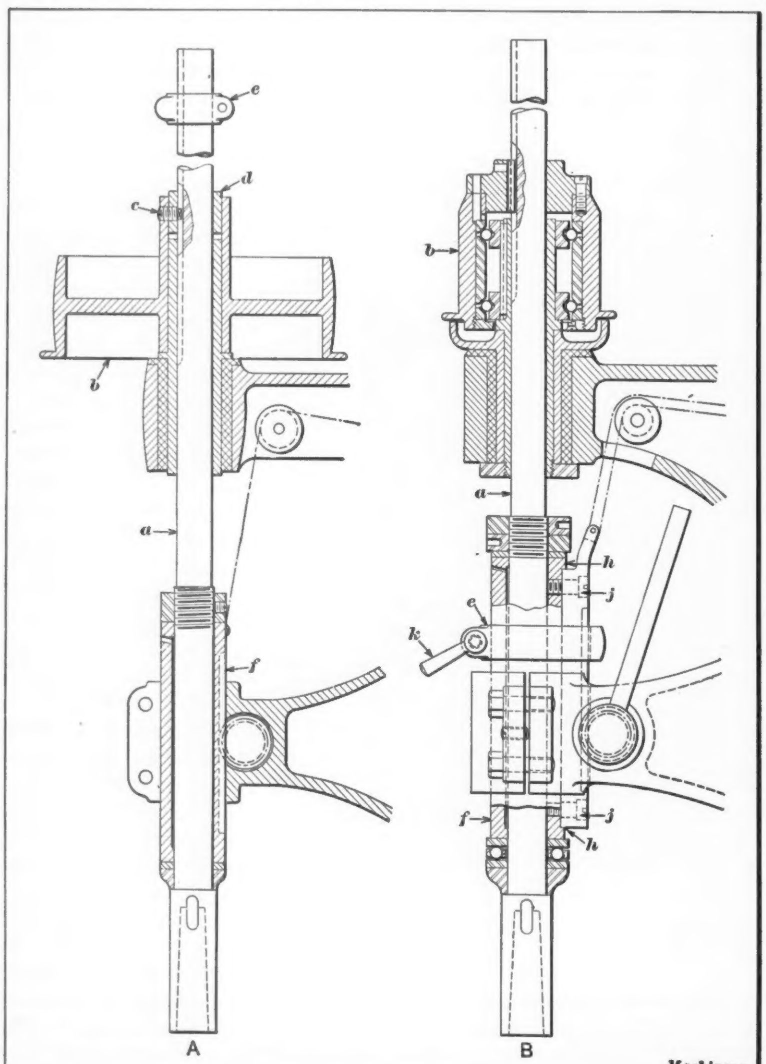


Fig. 4. (A) Spindle of Machine shown in Fig. 1. (B) A Design intended for High Speeds

screw *c* with lock-nuts *d*, that may be adjusted to any predetermined depth of hole, is a radical departure from those shown previously, although, perhaps not an altogether wise one. That the gage can be conveniently reached by the operator, and can be set to a very accurate depth is true, and there is no apparent objection to its application to a spindle with a short rack travel; nevertheless, on a long-travel sleeve it has frequently been found to pull the lower end of the sleeve forward, and, consequently, throw the spindle out of alignment, under ordinary pressure on the feed lever at the end of the stroke. What this means to the life and alignment of the machine is apparent.

### End Thrust Taken by Radial Type of Ball Bearing

The spindle shown at *A*, Fig. 3, has an annular bearing to take the drill thrust. Engineers for a long time were—and some still are—at variance as to the advisability of applying a thrust load on a radial type of ball bearing. Some makers of sensitive drilling machines and even a number of bearing manufacturers decry the use of the radial bearing in this capacity. While this contention may be justified theoretically, thorough experimenting, backed by subsequent daily observation in long running tests, has shown that a thrust load may be applied to an annular bearing, provided that the thrust load is from one-tenth to one-fourth of the rated radial capacity. It is even claimed, with good reason, that at speeds above 1500 revolutions per minute a radial thrust bearing is superior to the regular collar type bearing. This would be especially true in a sensitive drilling machine where high speeds go hand in hand with smaller sizes of drills and proportionately smaller thrusts. It is rather unfortunate that this function of the radial bearing has not been more fully comprehended by the average designer. This type not only absorbs less power in friction than the ordinary ball thrust but it lends itself to a much simpler and less expensive mounting. Its substitution for the thrust bearing on high-speed machinery is often the deciding factor in the success of the design.

### Method of Mounting Spindle Pulley

It is perhaps relevant at this point to describe an improvement in the spindle pulley design made simultaneously with the construction just described, but applied to a different type of drilling machine. This improvement, which is in the method of mounting the pulley, has some bearing on the question of high speed, although the change was made for an altogether different purpose. The view *B*, Fig. 3, illustrates a method of mounting the pulley with a bearing above and below and the belt pull in between. Heretofore, the drive key was located at the top of the pulley, and the distance between the drive and the drill caused the entire length of the spindle to be subjected to considerable torque when doing heavy drilling. This causes an intermittent jarring and vibration, to the detriment of the bearings and the accuracy of the machine in general. With the pulley mounting illustrated at *B*, the key is placed farther down and has more driving surface on the spindle keyway. This form of drive is ideal for low speeds and heavy work, and may be classed as the "heavy pattern"; the "light pattern" is shown at *A*, Fig. 5.

### Design that Proved a Failure Due to Method of Lubricating Ball Bearings

To return to the question of high speeds, the substantial design of pulley mounting shown at *B*, Fig. 3, combined with the spindle quill design that employed the annular type bearing for radial and thrust loads, was used as a basis for the construction illustrated at *A* in Fig. 6. With the addition of bearing *n* in the top of the quill, the problem was thought to resolve itself into the simple one of maintaining ample lubrication on the balls. This pulley design and others resembling it, are being used at present on different types of machines, sensitive drilling machines included, but all of these run at more or less moderate speeds. Any claims for this design at extremely high speeds are unfounded. It is well known that the most satisfactory lubricant for ball bearings operating at speeds below 2000 revolutions per minute is vaseline, thinned out to a certain extent with some light, acid-free mineral oil. As the speeds are increased and the temperatures rise accordingly, grease of any kind naturally loses its consistency, and for this reason a thin oil is substituted where high speed is essential. Some bearing manufacturers insist that grease is preferable even at the highest speeds, but even if this were true, the process of removing the dust-caps, clamping nuts and such parts for renewing the lubricant at intervals makes its use on the sensitive drilling machine undesirable. The task of lubricating the bearings on a machine usually devolves on the operator, and a renewal of this sort is often neglected, whereas an injection now and then with the oil-can is deemed a matter of routine.

The pulley mounting shown at *A*, Fig. 6, is designed to insure ample lubrication. The bushings *d* answer the purpose of reservoirs to keep the lubricant on a level with the ball bearings. The chief argument against this design is the great number of details necessary and the attendant cost of construction. This point would be well taken in regard to a slow-speed machine, but it would have been no detriment to the adoption of the design had the latter turned out to be suitable for the purpose for which it was made. The first test, however, established the fact that a bearing may be given too much lubrication, and that a ball bearing made to run at high speed in an oil bath is a predestined failure. The churning action of the balls, at the test speeds, caused the oil to become heated and finally to smoke. After a comparatively short period of running, the bearings and adjacent parts were found to be so hot that the design was pronounced a failure.

### Spindle which Operates Successfully at Speeds as High as 18,000 Revolutions per Minute

Up to this point, many things had been learned and unlearned in regard to spindle construction, but, as is apparent, no definite design was evolved that proved satisfactory at extremely high speeds. About this time the demand for a machine of this kind became insistent, whereupon was begun a thorough, scientific study of the numerous problems involved and a painstaking search for the solutions. Strange to say, the design shown at *A*, Fig. 6, formed the basis on which the successful construction was built. By a system of addition, elimination and substitution, and a strenuous testing of the machine after each alteration, the design shown at *B* was developed. This type of spindle arrangement is now in operation on hundreds of machines and many of them run constantly at speeds as high as 18,000 revolutions per minute without heating or excessive vibration. It has undergone rigid tests at 22,000 revolutions per minute and is recommended for a regular maximum speed of 12,000 revolutions per minute. There were so many vaguely defined stages in the development of this type, and its final achievement effected such important strides in sensitive drilling, that it may be well to relate in detail the difficulties that were encountered by manufacturers in their attempts to secure excessive speeds, and to summarize the methods employed in overcoming these obstacles and developing this final construction to its present stage of perfection.

The first question, and a very important one, is that of balancing. It is essential, of course, that all revolving parts have a perfect running balance both before and after assembling. The designer who adopts aluminum as the material for those pieces of largest diameters, has dispensed with seventy-five per cent of the trouble from vibration due to centrifugal force. The spindle is ground for its entire length and an additional keyway to balance the driving one is absolutely necessary. The long projecting spindle nose that provides for the use of taper shank drills is discarded and the chuck shank is ground directly on the spindle close up to the lower bearing, as shown. This means that the chuck must be furnished with the machine and must be of a type that is guaranteed to be in running balance. Nut *w* is provided to facilitate the removal of the chuck.

The problem of bearings has already been discussed. The annular bearing is used throughout the design and solves the problem of absorbing the thrust of the drill. For the reason that most drilling is performed with the head and table in the highest position, bearing *n* in the upper part of the sleeve is clamped some distance down in the sleeve to distribute the four bearings as evenly as possible over the entire length of the spindle. This is done also to avoid a binding action of the spindle between drive-key nut *o* and the bearing. A discrepancy of a fraction of a thousandth in the entire length from the top of the column bore to the bottom of the sliding head dovetail causes a retarding action of the spindle and a consequent slipping of the belt. This lowering of the bearing tends to equalize the error and allows the spindle to turn freely at all times. The pulley is mounted on a sleeve that gives a greater part of the spindle a sliding bearing. The spindle never projects beyond this sleeve enough to cause it to "whip", and is never visible above the top of the machine, the hood cap *p* covering it even in its highest position. The length of pulley sleeve *r* allows the bearings to be set far apart. The upper bearing *m* is held securely in the column and the lower one is held only on the sleeve, making the entire construction easily assembled. Every bearing is completely guarded against dust or grit; guard *s* covers the belt and pulley and the lower hood *t* covers the key bushing. The only exposed revolving part, aside from the drill chuck, is a section of the spindle between the spindle quill and the lower hood.

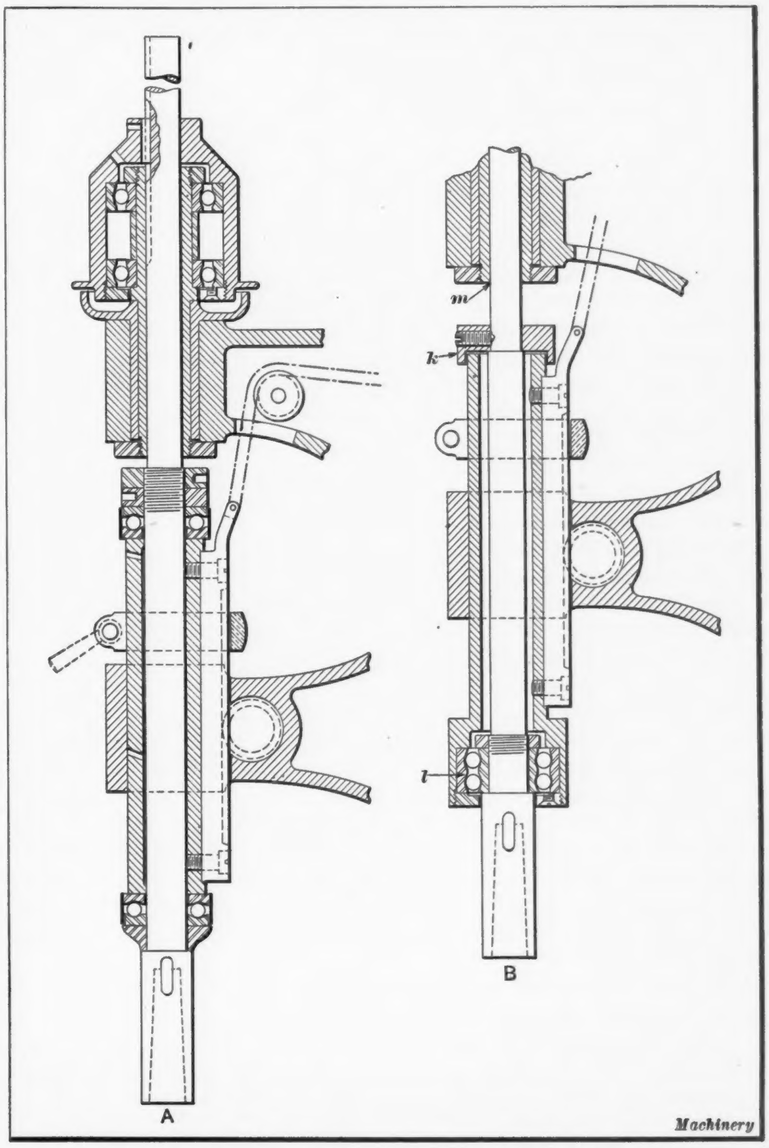


Fig. 5. (A) Another Step in Development of High-speed Spindle Construction. (B) Design intended to eliminate Sliding Friction in Sleeve Bearing

Next in importance to the type of bearings and their mounting is the method of lubrication. Many high-speed machines have ball bearing arrangements that permit the oil or grease to run off when it becomes heated, necessitating frequent renewal. The ideal way of oiling the bearing would be to station someone with an oil-can in close proximity to it to administer a drop or two of lubricant at frequent intervals. This method, everyone will agree, is entirely out of the question. However, the design illustrated is a close approximation to this condition. The oil is put in at *c* and settles in the cup formations in lower caps *e*. Attached to and revolving with the pulley sleeve are "flingers" *d* usually of spun copper. Bushings *k* have two oil-holes *l* that enter counterbores in the top leading to the bore of the bushing. The centrifugal action of these flingers impels the oil outward, and it is forced slowly upward in the oil-holes and thence onto and through the bearing. This practically amounts to a continuous circulation and, though the bearings receive ample lubrication, there is no opportunity

for the oil to become heated. Air holes *b* are provided so that there will not be a vacuum and a resultant escape of the oil beneath the flingers. This hole and the clearance between the flinger and the lower cap, are just large enough to allow a carefully calculated amount of lubricant to find its way to the bearings in the quill below. An occasional application of oil to the keyway above the spindle quill while the machine is not running further provides for lubricating these bearings.

The next consideration is the spindle itself. This is made as small in diameter as possible—consistent with the capacity of the machine—to keep the size of the bearings and the relative velocity of the balls down to a minimum. That it must be made from a good grade of steel is obvious. The equal distribution of the bearings, the location of the drive key as far down as possible and the compactness secured by chucking the drills directly below the lowest sleeve bearing combine to lessen the torsional strain on the spindle and correspondingly reduce the vibration of the machine.

The problem of driving belts is one that is solved only by the cooperation of sensitive drilling machine manufacturers and belt makers. After many tests with numberless round and flat belts of different materials and texture, a closely woven flat cotton belt, with a positive belt-tension arrangement, was found to be the type with the smallest amount of slippage at high speed. With the spindle shown at *B* running at a calculated speed of 20,000 revolutions per minute, the indicated speed was 18,050 revolutions per minute—an actual loss of about 10 per cent. Many sensitive drilling machines are sold at the speeds calculated from the driving and driven pulleys, and no thought is given to natural loss of speed due to the air cushion between the belt and the pulley, the small arc of contact on the spindle pulley, and the "jumping" of the belt on the idlers of belt-tension devices that are self-acting and not positive.

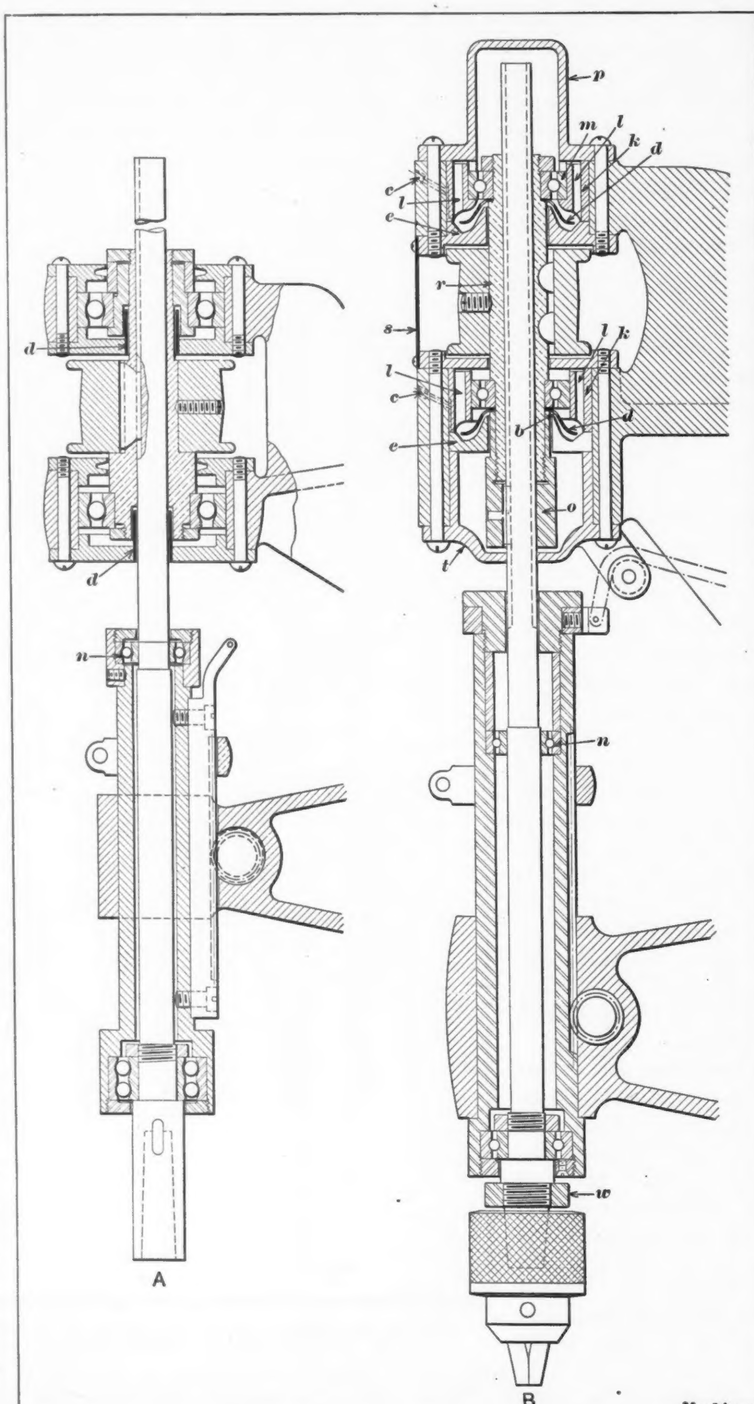


Fig. 6. (A) Design which proved a Failure owing to Method of Lubrication. (B) Spindle Construction capable of High Speeds

A modern type of high-speed, ball-bearing sensitive drilling machine with six spindles is shown in Fig. 2. This machine is equipped with the spindle construction shown at *B*, Fig. 6. A few years ago a six- or eight-spindle machine, with each spindle running from 3000 to 18,000 revolutions per minute, was considered an impossibility. A comparison of this machine with that shown in Fig. 1 illustrates the great progress made in a short time in the design of this hitherto neglected machine tool.

## ALCOHOL AS A FUEL FOR INTERNAL COMBUSTION ENGINES

A report has been published by the Commonwealth Advisory Council of Science and Industry of Australia dealing with alcohol as a fuel for internal combustion engines. The committee states that alcohol has been used with success for a number of years in Germany in specially designed engines. Any ordinary gasoline engine can be run on alcohol, except that it will not start on this fuel. The consumption of alcohol in ordinary gasoline engines is about 50 per cent greater than that of gasoline for equal power development. Engines specially designed for using alcohol, however, will not consume any more alcohol, by volume, per horsepower than the gasoline consumed in the operation of gasoline engines.

The main changes required in the design of an engine that is to use alcohol are increasing the compression to about 180 pounds per square inch, preheating the fuel and air, or the mixture of the two, and enlarging the fuel supply pipes. In starting, the carburetor should be preheated, or an arrangement must be made for using gasoline to start the engine. After once having started, the exhaust gases are used for preheating. It is easier to apply these changes in design and to use alcohol for stationary engines than for automobile engines, especially on account of the advantages of slow speeds and long piston strokes in engines using alcohol. The successful alcohol engines in Germany are almost wholly of the stationary type, and the records available indicate that comparatively little work has been done with a view to using alcohol as a fuel for automobile engines. It is possible that something may be done along these lines in the future.

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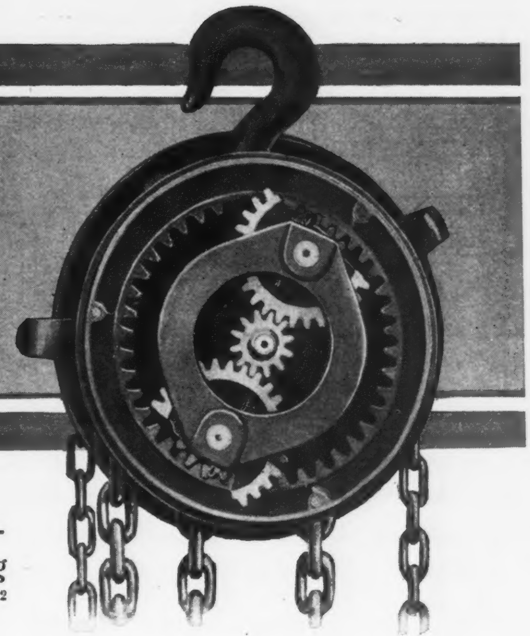
Cylindrical grinding of all shafts in machines is becoming common practice because of the economy of this method of machining and the superior quality of the work. A ground shaft is the last word in fine machine work, except the journals. A ground shaft journal is much improved by lapping in order to remove the microscopic ridges left by the grinding wheel and to impart a high polish. Lathe spindle journals may be lapped advantageously with ruby dust, especially if fitted in babbitt bearings. A lapped journal fitted to a well-proportioned babbitt bearing is a long-lived affair that will give no trouble if kept free from grit and supplied with oil.

# Differential Motions and Planetary Gear Combinations

By Franklin D. Jones[1]



*Second Installment of a Treatise on Mechanisms that Require Differential Motion and Methods of Determining Relative Velocities of Planetary or Differential Gears*[2]

In the first installment of this article, published in the March number of MACHINERY, a number of mechanisms having differential motions were described, including differential screw and hoist, differential planetary gearing, differential governors for water turbines, and differential gearing for automobiles. In this installment, which concludes the treatise, such subjects as speed regulation through differential gearing, differential hoisting mechanisms, reversal of motion, application of floating or differential levers, control mechanisms with differential motions, velocity ratio of planetary gears, and compound trains of planetary gearing will be taken up.

### Speed Regulation through Planetary or Differential Gearing

When the speed of a driven part is governed by drives from two different sources, differential gearing may be used to combine these drives and allow any variations in speed that may be required. An application of this kind is found on the fly frames used in cotton spinning for drawing out or attenuating the untwisted fiber or roving, by passing it between different pairs of rolls which move, successively, at increased speeds. After the fiber is attenuated, it is wound on bobbins and at the same time given a slight twist. The diagram Fig. 10 represents a mechanism for controlling the speed of the bobbins, one of which is indicated at *B*. This bobbin receives its motion through a train of gearing connecting with the main shaft of the machine and through another combination of gearing which is driven by a pair of cone pulleys for decreasing the speed of the bobbin, in revolutions per minute, in order to maintain a uniform peripheral speed as the roving is wound upon the bobbin and the diameter becomes greater.

The main shaft is driven by pulley *A*, and motion is transmitted through shaft *S* and the gearing shown to the cone *C* and the rolls, one of which is indicated at the upper part of the diagram. The cone *C* and the rolls move at a constant speed, and the roving is delivered by the rolls at a uniform rate of speed. On the shaft *S* there is a bevel gear *E*, which is one of the gears of a planetary train that is commonly known as the "differential motion." The large gear *D* corresponds to the arm of the gear train, since it carries the two intermediate bevel pinions *J* and *K*. Gear *D* is driven from the lower cone $C_1$, which is connected by belt with the upper cone. Bevel gear *F*, which meshes with the pinions carried by gear *D*, is loose on shaft *S* and is connected through gearing with the bobbin *B*. With this arrangement, the speed of the bobbin depends first upon the speed of bevel gear *E*, which is constant, and also upon the speed of gear *D*, which may be varied by shifting the position of the belt on the cones. Any variations in the relative speeds of gears *D* and *E* will produce twice the variations in the speed of the bobbin.

The roving is wound on the bobbin in successive helical layers by means of the flyer *H*, which is driven at constant speed by gear *M* on shaft *S*. The roving passes from the rolls to the flyer, and entering the top of its hollow spindle, is threaded down through one arm of the flyer and then wound on the bobbin. The flyer and bobbin revolve in the same direction, but the bobbin has a higher velocity and, for that reason, draws the roving from the flyer and winds it in successive layers as the bobbin travels up and down, so as to cover its entire surface. As each successive layer is added, the bobbin increases in diameter, and its rotative speed relative to that of the flyer must be decreased in order to prevent breaking the roving. This change of speed is transmitted to the bobbin through the differential gearing referred to by gradually shifting the belt on the cone pulleys.

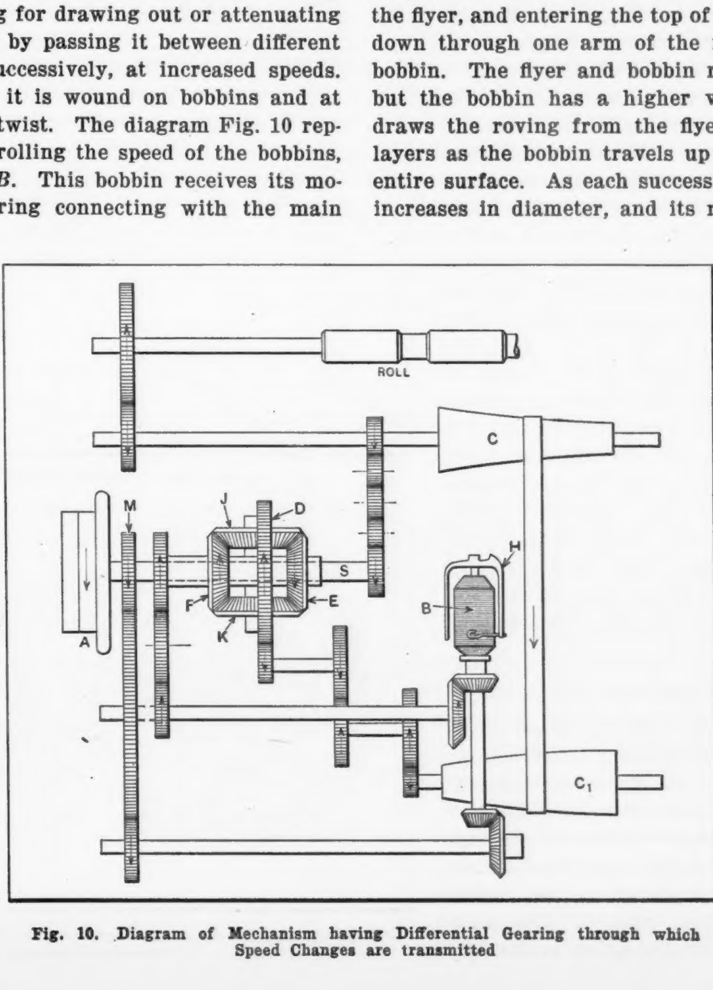



Fig. 10. Diagram of Mechanism having Differential Gearing through which Speed Changes are transmitted

### Differential Gear and Cam Combination

The differential gear and cam combination to be described is used on fly-frames in conjunction with the same general class of mechanism illustrated by the diagram Fig. 10. This mechanism differs from the differential ordinarily used in that it has no planetary train of gearing. As previously explained, a differential motion is employed in connection with a shifting belt and cone

[1]Associate Editor of MACHINERY
[2]A chapter that will be included in the author's book "Mechanisms and Mechanical Movements," to be published in the near future

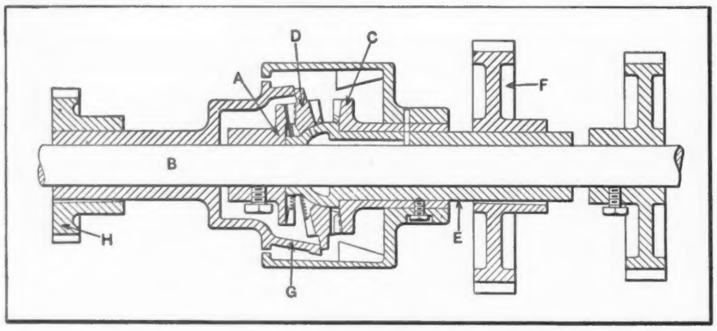



Fig. 11. Differential Gear and Cam Combination

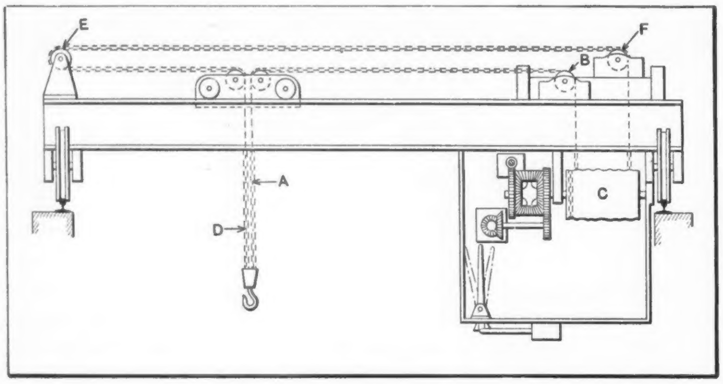



Fig. 12. Crane equipped with Differential Hoisting Mechanism shown diagrammatically in Fig. 13

pulleys for changing the speed of the bobbins. The differential action is obtained, in this case, by means of the crown gear *A*, Fig. 11, which is attached to the main driving shaft *B;* the crown gear *C* secured to sleeve *E*, which carries the bobbin-driving gear *F;* and the double crown gear *D*, which is mounted on a spherical seat and engages gears *A* and *C* at points diametrically opposite. This double crown gear operates in an oblique position, so that a small part of the gear meshes with gear *A* on one side and a small part on the other side meshes with gear *C*. The spherical bearing allows the intermediate crown gear *D* to swivel in any direction, and it is held in position by a cam surface on the edge of sleeve *G*. Gear *C* has the same number of teeth as intermediate gear *D*, but gear *A* has a somewhat smaller number of teeth.

The differential action is obtained by the relative motions between gear *A* and cam *G*. This cam is driven from the lower belt cone of the machine, which is connected with gear *H*. If cam *G* were revolving at the same speed as gear *A*, the same teeth on gears *A* and *D* would remain in contact and the entire gear combination would act practically the same as a clutch. As soon as the speed of the cam differs from that of gear *A*, the position of intermediate gear *D* is changed so that different teeth are successively engaged. As the result of this differential action, the speed transmitted to gear *C* is either increased or decreased. The extent of the differential motion depends upon the difference between the speeds of gear *A* and cam *G*. As this difference diminishes, the speed of gears *D* and *C* increases; when the speed of cam *G* is reduced, the speed of gear *C* is also reduced, since the motion from gear *A* is lost as the result of differential action. The advantages claimed for this mechanism are quiet operation and reduction of friction.

### Differential Hoisting Mechanism

An ingenious method of utilizing differential action to vary the speed of a hoisting mechanism is illustrated by the diagram Fig. 12, which is not shown as an example of modern crane design but merely to illustrate one of the many possible applications of planetary gearing. There are two chains attached to the crane hook. One of these chains *A* passes over a pulley on the trolley and over pulley *B* to the winding drum *C*. The other chain *D* passes upward over its trolley pulley to the left, and over pulley *E* to pulley *F*, and then down to a drum located back of drum *C*. These chains may be wound upon their respective drums either in opposite directions or in the same direction, and at varying rates of speed. If both drums are rotated in opposite directions at the same speed, the effect will be to raise or lower the hoisting hook, whereas, if the drums rotate in the same direction and at equal speed, the chain will be taken in by one and given off by the other, thus causing the hook and its load to be carried horizontally without raising or lowering it. Any difference in the speed of the two drums when moving either in the same or opposite directions will evidently cause the hook to move both vertically and horizontally at the same time.

The mechanism for operating the two hoisting drums is illustrated diagrammatically in Fig. 13. There are two electric motors *J* and *K*. Motor *J* drives the worm-wheels *L* in opposite directions and also the attached bevel gears. The other motor *K* drives the spur gears *M* and the upper bevel gears. The intermediate pinions *N* between the bevel gears revolve on arms *Q* which are keyed to the shafts of their respective drums. The bevel gears with which the pinions mesh are loose on their shafts. With this arrangement, if motor *K* is stationary, motor *J* will drive the drums in opposite directions and raise or lower the hook as previously explained. On the other hand, with motor *J* stationary, motor *K* will operate the drums in the same direction and move the crane hook horizontally. As these motors may be reversed or operated together at varying speeds, any desired combination of movements and speeds for the hook and its load may be obtained.

### Reversal of Motion through Planetary Gearing

A train of planetary gearing may be designed to give a reversal of motion. This form of transmission has been applied to some automobiles of the smaller sizes. The principle governing the operation of one of the earlier designs is shown by the diagram Fig. 14. Two sets of differential gears, indicated at *A* and *B*, are mounted inside drums. These drums may be revolved independently for obtaining the slow forward speed and a reverse motion, or they may be locked together

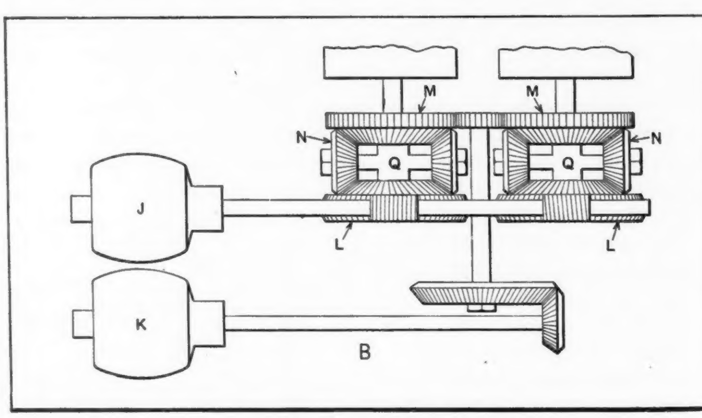



Fig. 13. Differential Hoisting Mechanism

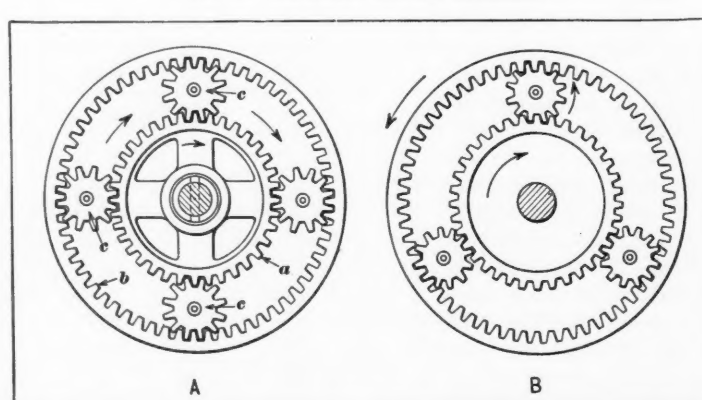



Fig. 14. Diagram showing Arrangement of Planetary Gearing for obtaining Forward and Reverse Motions

so as to revolve as a unit with the crankshaft for obtaining the direct high-speed drive. The central gear *a* is the driver in each case, and is keyed to the crankshaft. The slow forward speed is obtained with the combination illustrated at *A*. To obtain a reduction of speed, the internal gear *b* is held stationary by the application of a brake-band to its periphery; the pinions *c* carried by the driven member are then forced by the driving gear *a* to roll around inside the internal gear, thus transmitting a slow rotary motion to the driven member attached to the pinions. In order to obtain a reversal of motion through the combination of gearing illustrated at *B*, the disk carrying the pinions is prevented from rotating by the gripping action of another brake-band, so that the pinions merely revolve on their studs and rotate the internal gear in a reverse direction. In this case, the internal gear is the driven member, transmitting motion to the driving sprocket.

A reversal of motion may also be obtained with the train of planetary gearing shown in Fig. 16. In this case, there is no internal gear. Gear *A* is mounted on the sleeve of sprocket $A_1$, gear *D* is keyed to shaft *K*, and gear *F* is attached to the extended hub of drum *H*. The three gears *B*, *C*, and *E* are locked together and revolve upon a pin carried by drum *G*. A duplicate set is also located on the opposite side of the drum, as the illustration shows. When this drum is held stationary by a brake-band, gear *A* and sprocket $A_1$ are driven at a slow forward speed through gears *D*, *C*, and *B*, gears *D* and *A* revolving in the same direction. The direct high-speed drive is obtained when clutch *J* is engaged, the whole mechanism then revolving as a unit with shaft *K*. When drum *H* is held stationary by a brake-band, gear *D* causes gear *E* to revolve about the stationary gear *F* in a direction opposite to the rotation of *D*; consequently, gear *A* is forced to follow in the same direction in which drum *G* and the planetary gears *B*, *C*, and *E* are moving, thus reversing the motion of gear *A* and the sprocket.

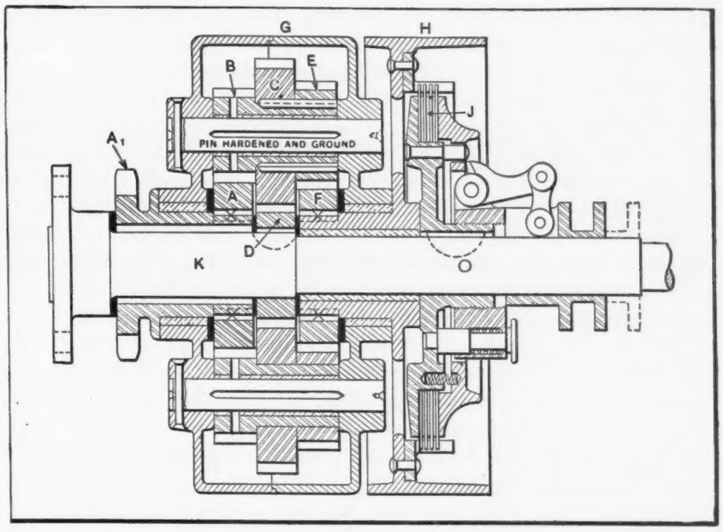



**Fig. 16. Another Arrangement of Planetary Gearing which gives Forward and Reverse Motions**

### Application of Floating or Differential Levers

What are known as "floating" or "differential" levers are utilized in some forms of mechanisms to control, by the application of a small amount of power or force, a much greater force, such as would be required for moving or shifting heavy parts. Floating levers are commonly applied to mechanisms controlling the action of parts that require adjustment or changes of position at intervals varying according to the function of the apparatus subject to control. The initial movement or force may be derived from a hand-operated lever or wheel, and the purpose of the floating lever is to so control the source of power that whatever part is to be shifted or adjusted will follow the hand-controlled movements practically the same as though there were a direct mechanical connection. A floating lever is so termed because it is not attached to fixed pivots and does not have a stationary fulcrum, but is free to move bodily, or to "float" within certain limits and in accordance with the relative forces acting upon the different connections.

Fig. 15 illustrates one application of the floating lever. The diagram at the left represents an auxiliary braking apparatus for a large hoist. The brake-shoe *A* is applied to the brake-drum *B* whenever the dead weight *C* rests upon the lever *D*. This lever is connected by rod *E* with a cross-head attached to the upper end of a piston-rod extending through the oil cylinder *F* and into the steam cylinder *G*. When steam is admitted beneath the piston in cylinder *G* by opening a valve at *H*, the weight is raised and the brake released, and, if, for any reason, the steam pressure should be suddenly reduced, weight *C* would fall and the brake be applied automatically. The movements of the piston in cylinder *G* and, consequently, of weight *C* are controlled by hand-lever *L* through floating lever *J*, in such a manner that the weight rises and falls, as the lever is shifted, practically the same as though the force for moving the weight were derived directly from the lever by means of a rigid mechanical connection. The action of the mechanism is as follows: If the weight is down and the brake applied, and lever *L* is moved from its central position to the right, the left-hand end of lever *J* will be raised (as shown on an exaggerated scale by diagram *X*), thus lifting rod *K* and opening valve *H;* this valve has no lap, so that any movement of the lever admits steam to the cylinder. As soon as the piston begins to rise, the right-hand end of lever *J* also rises (see diagram *Y*) and, turning about pivot *O*, immediately begins to close the steam valve. If lever *L* is moved through a small arc, the valve is closed quickly and the weight only rises a short distance; on the contrary, if the lever is thrown over to the extreme position, the piston and weight must move upward a proportionately greater distance before the valve is closed. If the lever, after being thrown to the right, is moved toward the left, valve *H* opens the exhaust port and the weight descends; as soon as it begins to move downward, the left-hand end of the floating lever is raised, which tends to close the exhaust port and prevent further downward motion.

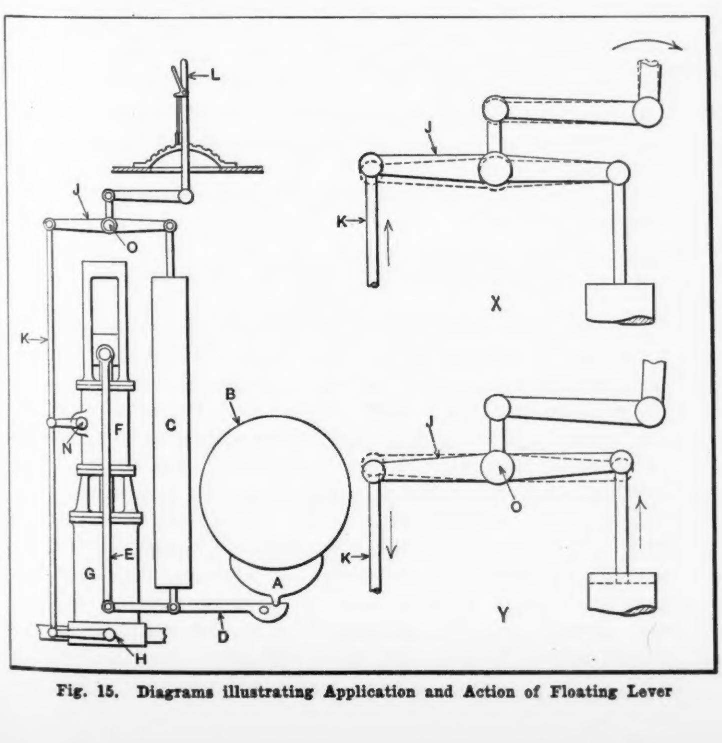



**Fig. 15. Diagrams illustrating Application and Action of Floating Lever**

An apparatus of this kind responds so quickly to adjustment that the weight follows the motion of the hand-lever almost instantaneously and the end of the floating lever connected to rod *K* has little actual movement. The oil cylinder *F* is used to stabilize the action of the weight and prevent over-travel which would occur if there were only the cushioning effect of

steam. The by-pass valve $N$ controls the flow of oil from one end of the cylinder to the other as the piston moves up or down, so that the motion of the weight ceases as soon as the steam and oil valves are closed.

### Differential Controlling Mechanism of Steering Gear

The practical effect of the floating lever previously described for controlling the movements of power-driven apparatus may be obtained by other mechanical devices, examples of which are found on steamships for controlling the action of the steering engines. Engines used for this purpose are commonly equipped with a control valve which distributes steam to the engine valves. The latter are generally of the hollow piston type and are arranged to receive steam either at the ends or in the center, the exhaust varying accordingly. The admission of steam either to the ends or in the center is governed by the position of the control valve. For instance, if the control valve is moved in one direction, steam may be admitted to the ends of the engine valves and be exhausted in the center. If the control valve is moved in the opposite direction, this order is reversed and also the direction in which the engine rotates; therefore, each engine valve requires but one eccentric, the control valve acting as a reversing gear. The mechanism which operates this control valve is so designed that, when the engine is set in motion to move the rudder either to port or starboard, this same motion is utilized to shift the control valve in such a way that the movement of the rudder coincides with the motion of the steering wheel. While the floating lever has been used in connection with this controlling mechanism, the common form of control depends upon the action (which is often differential) either of gearing or of a screw and nut.

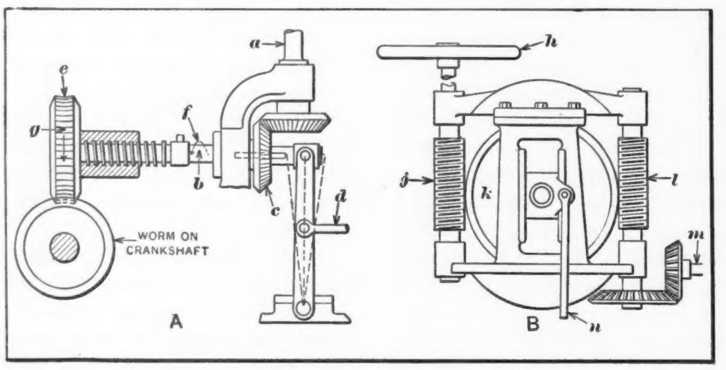



Fig. 17. (A) Controlling Device for Steering Gear. (B) Mechanism used as Substitute for a Floating Lever

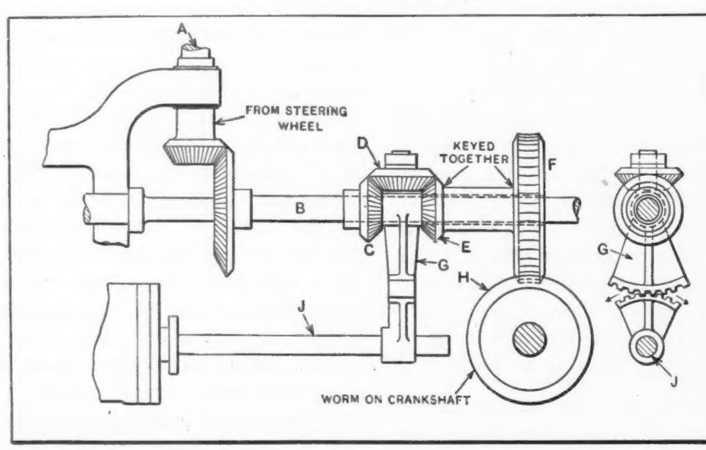



Fig. 18. Steering Gear Control Mechanism having Differential Bevel Gearing

With the arrangement illustrated at $A$, Fig. 17, the control valve of a steering engine is governed by the action of a screw that is operated by the steering wheel, and a nut that is revolved by the engine. The shaft $a$ is connected with the steering wheel and transmits rotary motion to screw $b$ which is splined to, and free to slide through, gear $c$. The rod $d$ serves to operate the control valve of the steering engine. Any rotary motion of shaft $a$ moves screw $b$ in a lengthwise direction in or out of the nut on worm-wheel $e$, unless this nut is revolving at the same speed as the screw. The action of the mechanism is as follows: If worm-wheel $e$, which meshes with a worm on the steering engine crankshaft, is stationary, the rotation of shaft $a$ will turn screw $b$ in or out of the nut and shift the control valve, thus starting the engine in one direction or the other, depending upon which way the control valve is moved. As soon as the engine starts, worm-wheel $e$ and the nut begin to revolve, which tends to move the screw and control lever in the opposite direction. Suppose screw $b$ were revolved in the direction shown by the arrow $f$, thus moving the screw and control lever to the right; then, as the engine starts, worm-wheel $e$ and the nut revolve as shown by the arrow $g$. Now as soon as the rotation of shaft $a$ and screw $b$ is stopped or is reduced until the speed of rotation is less than that of worm-wheel $e$, the screw is drawn back into the nut and the control valve is closed. If the steering wheel and screw $b$ were turned slightly and then stopped entirely, the rudder would be moved only a corresponding amount, because the control valve would soon be shifted, by the action of worm-wheel $e$, to the closed position. Steering engines, in general, are equipped with some form of stopping device which automatically limits the movement of the rudder and prevents over-travel and damaging the mechanism.

### Steering Gear Control Mechanism having Planetary Bevel Gearing

The steering-gear controlling mechanism illustrated in Fig. 18 operates on the same general principle as the design previously described, although the construction is quite different. The control valve, in this case, operates with a rotary motion, instead of moving in a lengthwise direction. Shaft $A$ is revolved by the steering wheel and transmits rotary motion to shaft $B$ through the gearing shown. The differential action for regulating the position of the control valve is obtained by means of three gears $C$, $D$, and $E$. Gear $C$ is keyed to shaft $B$, and gear $E$ on the extended hub of worm-wheel $F$ is free to revolve about shaft $B$. Gear $D$ interposed between gears $C$ and $E$ is mounted upon a segment gear $G$ which engages another segment gear on the control valve spindle $J$. If shaft $B$ is revolved while gear $E$ and the worm-wheel are stationary, gear $D$ rolls around between the gears and, through the segment gear, turns the control valve, thus starting the steering engine and with it the worm $H$ on the crankshaft which drives worm-wheel $F$ and gear $E$. As soon as the rotation of shaft $B$ is stopped, gear $E$ which has been revolving in the opposite direction to that of $C$ rolls gear $D$ back to the top position, thus closing the control valve and stopping the engine. If gears $C$ and $E$ are revolved at the same speed, gear $D$ simply rotates between them and the control valve remains open. If the speed of gear $E$ exceeds that of $C$, the valve begins to close, and if $C$ revolves faster than $E$, the valve is opened wider and the engine continues to operate.

### Rolling Worm-wheel Type of Controlling Mechanism

The ingenious substitute for the floating lever, illustrated at $B$ in Fig. 17, depends for its action upon a worm-wheel which is interposed between two worms. The handwheel $h$ controls the rotation of worm $j$, which meshes with the worm-wheel $k$. The worm $l$ on the opposite side of the worm-wheel is rotated by whatever apparatus is to be controlled. The shaft of the worm-wheel is journaled in boxes which are free to slide up and down the vertical slides in the framework shown. Any vertical displacement of the worm-wheel is transmitted to rod $n$ which operates the valve, clutch, or other mechanical device used for starting, stopping, and reversing the driving machinery. Assume that the mechanism is at rest with the worm-wheel midway between its upper and lower positions in the

vertical slides of the housing. When the handwheel $h$ is revolved in a direction corresponding to the motion desired, worm $j$ revolves, and worm $l$ is stationary, since the mechanism is not yet in motion; therefore, the rotation of the handwheel has the effect of rolling the worm-wheel $k$ between the two worms either up or down, depending upon the direction in which the handwheel is rotated. Any vertical displacement of the worm-wheel will, through the medium of controlling rod $n$, start the power-driven machinery. This motion is immediately transmitted to shaft $m$ and worm $l$ which acts to move worm-wheel $k$ in the opposite direction vertically, provided worm $j$ is stationary or is revolving slower than $l$. The result is that the power-driven member is moved or adjusted proportionately to the rotation of the handwheel $h$. The handwheel, for instance, might be turned to a position corresponding to a certain required adjustment, which would then be made automatically. The operation of this controlling device is based on the same general principle as the steering-gear controlling mechanisms previously described.

### Velocity Ratios of Planetary Gears

Determining the relative speeds of planetary gears is often complicated somewhat because of confusion as to the relative motions and the distinction between the rotation of a planetary gear about its own axis and its rotation relative to a fixed plane or stationary part of the mechanism. To begin with, the relative speeds of a pinion and gear arranged as shown at $A$, Fig. 19, will be considered. These two gears are held in mesh by a link $c$. If this link remains stationary and gear $a$ makes one revolution, the number of revolutions made by gear $b$ will equal the number of teeth in $a$ divided by the number of teeth in $b$, or the pitch diameter of $a$ divided by the pitch diameter of $b$. If $a$ and $b$ represent either the pitch diameters of the gears or the numbers of teeth, the revolutions of $b$ to one turn of $a$ equal $\frac{a}{b}$.

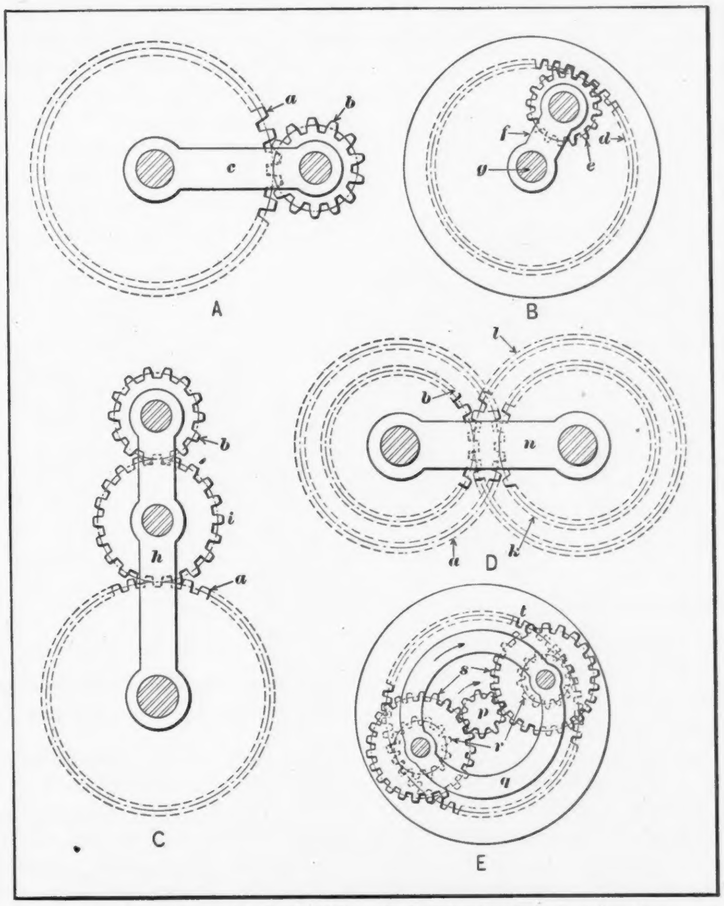



Fig. 19. Differential Combinations of Planetary or Epicyclic Gearing

If gear $a$ is held stationary and link $c$ is given one turn about the axis of $a$, then the revolutions of gear $b$, relative to arm $c$, will also equal $\frac{a}{b}$, the same as when gear $a$ was revolved once with the arm held stationary. Since a rotation of arm $c$ will cause a rotation of gear $b$ in the same direction about its axis the total number of revolutions of gear $b$, relative to a fixed plane for one turn of $c$, will equal 1 (the turn of $c$) plus the revolutions of $b$ relative to $c$, or $1 + \frac{a}{b}$. For example, if gear $a$ has 60 teeth and gear $b$, 20 teeth, one turn of arm $c$ would cause $b$ to rotate $\frac{60}{20}$, or 3 times about its own axis; gear $b$, however, also makes one turn about the axis of gear $a$, so that the total number of revolutions relative to a fixed plane equals $1 + \frac{60}{20} = 4$ revolutions.

In order to illustrate the distinction between the rotation of $b$ around its own axis and its rotation relative to a fixed plane, assume that $b$ is in mesh with a fixed gear $a$ and also with an outer internal gear that is free to revolve. If the speed of the internal gear is required, it will be necessary, in calculating this speed, to consider not only the rotation of $b$ about its own axis, but also its motion around $a$, because the effect of this latter motion on the internal gear, for each turn of link $c$, is equivalent to an additional revolution of $b$.

Diagram $B$ represents an internal gear $d$ in mesh with gear $e$ on arm $f$. If arm $f$ is held stationary, the revolutions of $e$ for one turn of $d$ equal $\frac{d}{e}$, $d$ and $e$ representing the numbers of teeth or pitch diameters of the respective gears. If the internal gear is held stationary and arm $f$ is turned about axis $g$, the rotation of $e$ about its axis will be clockwise when $f$ is turned counter-clockwise, and *vice versa*; hence, the revolutions of gear $e$, relative to a fixed plane, for one turn of $f$ about $g$, will equal the difference between 1 (representing the turn of $f$) and the revolutions equal to $\frac{d}{e}$.

### Analysis of Planetary Gear Trains

A simple method of analyzing planetary or epicyclic gearing, which has been applied extensively by designers, etc., is to consider the actions separately. For instance, with the gearing shown at $A$, Fig. 19, the results obtained when link $c$ is fixed and the gear $a$ (which normally would be fixed) is revolved are noted; if gear $a$ is revolved in a clockwise direction, then, in order to reproduce the action of the gearing, the entire mechanism, locked together as a unit, is assumed to be given one turn counter-clockwise. The results are then tabulated, using plus and minus signs to indicate directions of rotation. Assume that gear $a$ has 60 teeth and gear $b$, 20 teeth, and that + signs represent counter-clockwise movements and — signs, clockwise movements. If link $c$ is held stationary and gear $a$ is turned clockwise (—) one revolution, gear $b$ will revolve counter-clockwise (+) 60/20 revolution. Next consider all the gears locked together so that the entire combination is revolved one turn in a counter-clockwise (+) direction, thus returning gear $a$ to its original position. The practical effect of these separate motions is the same as though link $c$ were revolved once about the axis of a fixed gear $a$ which is the way in which the gearing operates normally. By tabulating these results as follows, the motion of each part of the mechanism may readily be determined.

| | Gear a | Link c | Gear b |
|---|---|---|---|
| Link stationary...... | —1 turn | 0 turn | + 60/20 turn |
| Gears locked........ | +1 turn | +1 turn | +1 turn |
| Number of turns.... | 0 | +1 | +4 |

The algebraic sums in the line headed "Number of Turns" indicate that, when gear $a$ is held stationary and link $c$ is given one turn about the axis of $a$, gear $b$ will make 4 revolutions relative to a fixed plane in a counter-clockwise or + direction, when link $c$ is turned in the same direction.

The application of this method to the arrangement of gearing shown at $B$ will now be considered. Assume that gear $d$

has 60 teeth and gear *e*, 20 teeth. Then, if gear *d* is turned clockwise with link *f* stationary, and the entire mechanism with the gears locked is turned counter-clockwise, an analysis of the separate motions previously referred to will give the following results:

| | Gear d | Link f | Gear e |
|---|---|---|---|
| Link stationary...... | —1 turn | 0 turn | —60/20 turn |
| Gears locked........ | +1 turn | +1 turn | +1 turn |
| Number of turns..... | 0 | +1 | —2 |

### Effect of Idler in Planetary Gear Train

If an idler gear *i* is placed between gears *a* and *b* (diagram *C*, Fig. 19), the latter will rotate about its axis in a direction opposite to that of the link (the same as with the arrangement shown at *B*), and the revolutions of gear *b*, relative to a fixed plane, for one turn of link *h* about the axis of *a*, will equal the difference between 1 (representing the turn of *h*) and the revolutions equal to $\frac{a}{b}$. Assume that gear *a* has 60 teeth, idler gear *i*, 30 teeth, and gear *b*, 20 teeth. Then the turns of *b*, relative to a fixed member for one turn of *h* about the axis of *a*, are shown by the following analysis:

| | Gear a | Idler i | Link h | Gear b |
|---|---|---|---|---|
| Link stationary. | —1 turn | + 60/30 turn | 0 turn | — 60/20 turn |
| Gears locked.... | +1 turn | +1 turn | +1 turn | +1 turn |
| Number of turns. | 0 | +3 | +1 | —2 |

The direction of rotation of *b*, relative to a fixed member, may or may not be in the same direction as that of link *h*, depending upon the velocity ratio between gears *a* and *b*. If gears *a* and *b* are of the same size, one turn of link *h* will cause *b* to revolve once about its own axis, but, as this rotation is in a direction opposite to that of *h*, one motion neutralizes the other, so that *b* has a simple motion of circular translation relative to a fixed member. If gear *b* were twice as large as *a*, it would then revolve, for each complete turn of link *h*, one-half revolution about its own axis, in a direction opposite to the motion of *h*; this half turn subtracted from the complete turn of link *h* gives a half turn in the same direction as *h*, relative to a fixed member.

### Compound Train of Planetary Gearing

Diagram *D*, Fig. 19, illustrates a compound train of planetary gearing. This arrangement modified to suit different conditions is commonly employed. Gear *a* represents the fixed member and meshes with gear *k*, which is attached to the same shaft as gear *l*. Gear *l* meshes with gear *b* the axis of which coincides with that of fixed gear *a*. Assume that gear *a* has 36 teeth, gear *k*, 34 teeth, gear *l*, 35 teeth, and gear *b*, 35 teeth. Then one turn of link *n* about the axis of gear *a* would give the following results:

| | Gear a | Link n | Gears k and l | Gear b |
|---|---|---|---|---|
| Link stationary. | —1 turn | 0 turn | $+\frac{36}{34}$ turn | $-(\frac{36}{34}\times\frac{35}{35})$ turn |
| Gears locked... | +1 turn | +1 turn | +1 turn | +1 turn |
| Number of turns | 0 | +1 | +2 1/17 | —1/17 |

From this analysis, it will be seen that, for each counter-clockwise turn of link *n*, the rotation of gear *b* equals $1 - \frac{a}{k} \times \frac{l}{b}$, in which the letters correspond either to the pitch diameters or numbers of teeth in the respective gears shown at *D*. If the value of $\frac{a}{k} \times \frac{l}{b}$ is less than 1, gear *b* will revolve in the same direction as link *n*, whereas, if this value is greater than 1, gear *b* will revolve in the opposite direction.

Compound planetary gearing may be used for obtaining a very great reduction in velocity between the link *n* and the last gear *b* in the train. As an extreme example, suppose gear *a* has 99 teeth, gear *k*, 100 teeth, gear *l*, 101 teeth, and gear *b*, 100 teeth.

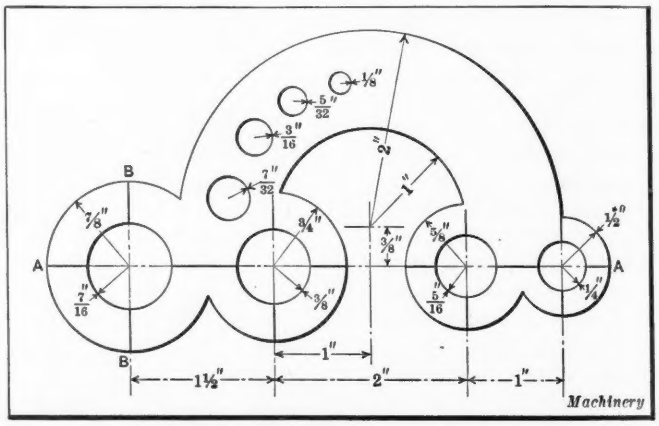
The speed of gear *b* will equal $1 - \frac{99 \times 101}{100 \times 100} = \frac{1}{10{,}000}$ revolution; hence link *n* would have to make 10,000 revolutions for each revolution of gear *b*. The arrangement of planetary gearing shown at *D* is known as a "reverted train."

Diagram *E* shows another arrangement of a reverted train. An internal gear *t* forms part of the mechanism, and either this gear, frame *q*, or pinion *p* may be the stationary member, depending upon the application of the mechanism. In this case, instead of a single set of gears between *p* and *t*, there is a double set located diametrically opposite and connected by a suitable frame *q*. This arrangement is similar to the mechanism of a certain type of geared hoist. The central pinion *p* is the driving member, internal gear *t* is stationary, and the frame *q* is the driven member and imparts motion to the hoisting sheave.

* * *

## RADIUS JIG FOR DRAFTSMEN

The radius jig (see illustration) is so named because it is intended for use whenever an arc is to be drawn tangent to two straight lines. Drawing fillets on casting details and round corners are examples of work for which the radius jig is adapted. When the arc is to be tangent to two lines at right angles, the center lines *AA* and *BB* may be used to determine the points of tangency. This jig saves the time usually required for finding the center of the arc when using a compass. It may be made of celluloid 0.020 to 0.030 inch thick. This celluloid may be obtained from the scrap bag of an upholstery shop. When laying out the jig, the radii given on the drawing should be 1/64 inch short for an external radius and 1/64 inch long for an internal radius to allow for the width




Radius Jig for drawing Arcs Tangent to Straight Lines

of the pencil point. When cutting out the circular edges, a pair of draftsman's dividers will be found to work very well, one point of the dividers being used as a cutting edge. Care should be taken not to exert too much pressure on the cutting point, as the dividers will spread and spoil the edge. The external arcs should be cut first, thus leaving centers for cutting the inner circles. A piece of fine emery cloth should be used to smooth the edges after cutting. Numbers may be scratched or cut upon the surface to designate the radii of the different arcs and curves, but after this jig has been used a short time, the draftsman will remember the location of the different sizes and the figures will no longer be needed. The scrap material, when cut to the proper size, makes excellent washers for bow instruments and ruling pens, two washers being used on each screw, so that one will slide upon the other when making adjustments. C. A. C.

* * *

The importance of securing greater uniformity than now exists in mathematical and other symbols in the various engineering fields has long been recognized. A committee of the American Association for the Advancement of Science took the matter in hand some time ago and made efforts to secure international cooperation. It is now advocated that American scientists and engineers should not wait for international agreement, but should standardize symbols for their own use. In normal times, this would be considered a most unfortunate suggestion, but it is obviously the only method feasible at present.

# SPEEDS AND FEEDS FOR DRILLING[1]

**METHODS OF DETERMINING PROPER CONDITIONS OF OPERATION—EFFECT OF HIGH-SPEED UPON EFFICIENCY OF TWIST DRILLS**

BY EDWARD K. HAMMOND[2]

THERE are so many variables which enter into the performance of a drilling operation that it is extremely difficult to establish anything in the nature of hard and fast rules for the speed and feed that are correct for drilling a hole of specified size in a given class of material. It is quite general practice for an experienced mechanic to determine what appears to him to be the proper speed and feed for a given job by the use of "cut and try" methods. Experience will enable him to tell very closely what are the proper conditions of operation, and with this as a basis he will observe the operation of the drill and from that judge whether he is working under conditions that yield the maximum production. The successful use of high-speed steel drills often depends more upon the conditions under which they are operated than upon the tools themselves, provided they are properly made from a suitable grade of steel.

### Concerning Desirability of Drilling at High Speed

Recent years have witnessed great increases in the speed at which drilling operations are performed in many shops, and the advocates of high-speed drilling—both among builders of drilling machines and users of such equipment—claim that numerous advantages are secured by drilling at these high speeds. There is another body of mechanical men who scout the idea of benefits resulting from high-speed drilling, and state that this is a fad which has been carried to great excess. In any case, the proper speed at which a drilling operation should be performed is that speed at which the most desirable balance is obtained between cutting down of production through lowering the drilling speed and loss of time through the necessity of more frequently stopping the drilling machine to grind drills, where higher drilling speeds are employed. Owing to this diversity of opinion in regard to the most efficient speed at which drilling operations can be performed, the following recommendations made by different authorities should prove of interest and practical value.

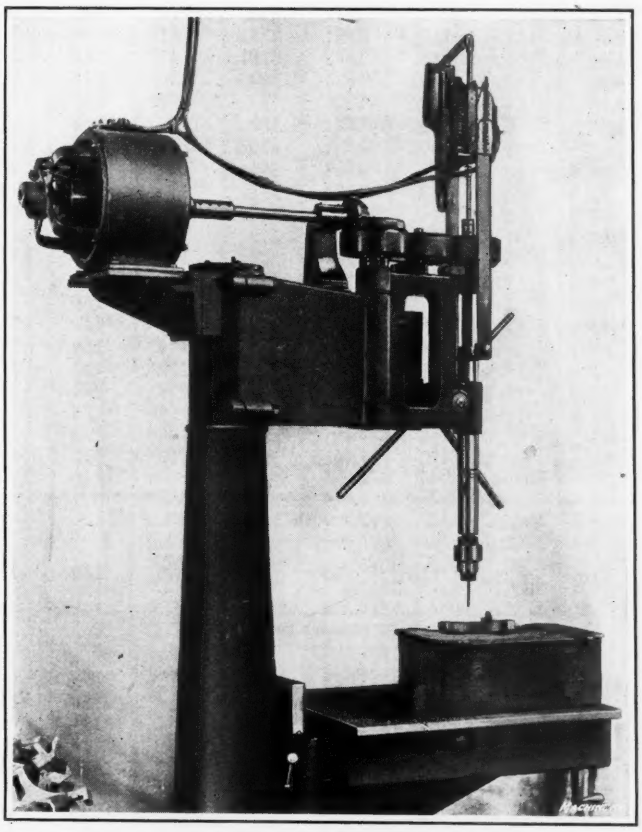


Fig. 1. Radial Drilling Machine equipped with "Magic" Quick-change Chuck and Automatic Control for Variable-speed Motor Drive to assure Proper Cutting Speed for All Tools

H. M. Norris, chief engineer of the Cincinnati-Bickford Tool Co., has made a careful study of the question of drilling speeds, and the results of his investigations have led him to the conclusion that occasionally a drill is found which is capable of standing up satisfactorily at a cutting speed of 150 feet per minute in either cast iron or steel, but it is seldom desirable to drive anything but very small drills at speeds in excess of 100 feet per minute. Under average conditions of operation, the best results will be obtained with a cutting speed of 80 feet per minute in cast iron, while for steel, a speed of $\frac{12}{d} + 76$ feet per minute will give satisfactory results. Where this rule is used, the cutting speed will be decreased from 100 feet per minute for a 1/2-inch drill to 80 feet per minute for a 3-inch drill. In explaining the rule, attention is called to the fact that, while cast iron is cut dry, a lubricant is required for drilling steel and a volume of lubricant sufficient to keep a 1/2-inch drill cool at 100 feet per minute will only be sufficient to cool a 3-inch drill at 80 feet per minute.

Selection of the proper speed and feed for a given drilling operation is governed by the diameter of the drill and the kind of material being drilled. Exhaustive tests and close observation of the Cleveland Twist Drill Co. have led to the conclusion that in establishing the best conditions of operation for a given job, it is well to start carbon steel twist drills under the following conditions of speed and feed until more definite data are available as to the maximum speed and feed which can properly be employed for the operation under consideration. When drilling machine steel use a peripheral speed of 30 feet per minute; for cast iron use a speed of 35 feet per minute; and for brass use a speed of 60 feet per minute. In each case a feed of 0.004 to 0.007 inch per revolution should be employed for drills up to 1/2-inch in diameter, while for larger sizes the feed should be from 0.005 to 0.015 inch per revolution. In the case of high-speed steel drills the preceding rates of speed should be increased from 100 to 125 per cent, while the same rates of feed are employed. The Standard Tool Co. recommends starting high-speed steel drills at a peripheral speed of from 50 to 70 feet per minute for wrought iron or steel, and from 60 to 80 feet per minute for cast iron, or at 140 feet per minute for brass. The feeds recommended are 0.004 inch per revolution for a 1/16-inch drill in wrought iron or steel, 0.005 inch per revolution for a 1/4-inch drill, 0.008 inch per revolution for a 1/2-inch drill, 0.010 inch per revolution for a 1-inch drill, and 0.015 inch per revolution for a 1½-inch drill.

The Detroit Twist Drill Co. states that high-speed steel drills can often be run efficiently at over 100 feet per minute in cast iron, but that better results will usually be obtained at 60 to 70 feet per minute. In establishing the proper conditions for a given drilling operation, a freshly ground drill of a given size should be tested at each of the two speeds provided by the machine above and below that which is necessary to give a cutting speed of 70 feet per minute, and then each successive feed provided on the machine should be tried until one is found at which the drill will run without slowing down the machine or injuring the drill during a period of one hour's operation, which is the standard shop interval during which a drill should operate without requiring grinding. This sounds as if it would require considerable time, but, as a matter of

[1] For previous articles on drilling practice, see "Modern Drilling Practice," in the January, February, and March numbers of MACHINERY

[2] Associate Editor of MACHINERY

fact, establishment of speeds and feeds by this method can be quickly accomplished and the saving will more than compensate for the time spent in determining the most efficient conditions of operation where there are a large number of parts to be drilled. For drilling wrought iron or steel, the drill should be started at a peripheral speed of from 50 to 70 feet per minute, for cast iron the speed should be from 60 to 80 feet per minute, and for brass, from 100 to 150 feet per minute. Under favorable conditions, the feed should be 0.004 inch per revolution for a 1/16-inch drill in wrought iron or steel, 0.005 in per revolution for a 1/4-inch drill, 0.008 inch for a 1/2-inch drill, 0.010 inch for a 1-inch drill, and 0.015 inch for a 2-inch drill. If the drill breaks or chips on the cutting edges, the rate of feed should be reduced.

## TABLE 1. CUTTING SPEEDS

| Diam., Inches | FEET PER MINUTE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 |
| | Revolutions per Minute | | | | | | | | | | | | | | |
| 1/16 | 917. | 1223. | 1528. | 1834. | 2140. | 2445. | 2751. | 3057. | 3363 | 3668 | 3974 | 4280. | 4586 | 4891 | 5197 |
| 1/8 | 459. | 611. | 764. | 917. | 1070. | 1222. | 1375. | 1528. | 1681 | 1834 | 1986 | 2139 | 2292 | 2445 | 2598 |
| 3/16 | 306. | 408. | 509. | 611. | 713. | 815. | 917. | 1019. | 1121 | 1222 | 1325 | 1426 | 1529 | 1630 | 1732 |
| 1/4 | 229. | 306. | 382. | 458. | 535. | 611. | 688. | 764. | 851 | 917 | 994 | 1070 | 1147 | 1222 | 1300 |
| 5/16 | 183. | 245. | 306. | 367. | 428. | 489. | 550. | 611. | 672 | 733 | 794 | 856 | 917 | 978 | 1039 |
| 3/8 | 153. | 204. | 255. | 306. | 357. | 408. | 458. | 509. | 560 | 611 | 662 | 713 | 764 | 815 | 865 |
| 7/16 | 131. | 175. | 218. | 262. | 306. | 349. | 393. | 437. | 481 | 524 | 568 | 611 | 656 | 699 | 743 |
| 1/2 | 115. | 153. | 191. | 229. | 268. | 306. | 344. | 382. | 420 | 459 | 497 | 535 | 573 | 611 | 649 |
| 9/16 | 102. | 136. | 170. | 204. | 238. | 272. | 306. | 340. | 373 | 407 | 441 | 475 | 509 | 543 | 577 |
| 5/8 | 91.8 | 123. | 153. | 184. | 214. | 245. | 276. | 306. | 337 | 367 | 398 | 428 | 459 | 489 | 520 |
| 11/16 | 83.3 | 111. | 138. | 167. | 194. | 222. | 249. | 273. | 300 | 333 | 360 | 389 | 416 | 444 | 472 |
| 3/4 | 76.3 | 102. | 127. | 153. | 178. | 203. | 229. | 254. | 279 | 306 | 330 | 357 | 381 | 408 | 432 |
| 13/16 | 71.1 | 94.8 | 119. | 142. | 166. | 190. | 213. | 237. | 261 | 284 | 308 | 332 | 356 | 379 | 403 |
| 7/8 | 65.5 | 87.3 | 109. | 131. | 153. | 175. | 196. | 219. | 241 | 262 | 285 | 306 | 329 | 349 | 372 |
| 15/16 | 61.0 | 81.4 | 101. | 122. | 142. | 163. | 183. | 204. | 224 | 244 | 265 | 285 | 305 | 326 | 346 |
| 1 | 57.3 | 76.4 | 95.5 | 115. | 134. | 153. | 172. | 191. | 210 | 229 | 258 | 267 | 287 | 306 | 325 |
| 1 1/16 | 53.9 | 71.8 | 89.8 | 108. | 126. | 144. | 162. | 180. | 197 | 215 | 233 | 251 | 269 | 287 | 305 |
| 1 1/8 | 51.0 | 68.0 | 85.0 | 102. | 119. | 136. | 153. | 170. | 187 | 204 | 221 | 238 | 255 | 272 | 289 |
| 1 3/16 | 48.3 | 64.4 | 80.5 | 96.6 | 113. | 129. | 145. | 161. | 177 | 193 | 209 | 225 | 242 | 258 | 274 |
| 1 1/4 | 45.8 | 61.2 | 76.3 | 91.8 | 107. | 123. | 137. | 153. | 168 | 183 | 199 | 214 | 230 | 245 | 260 |
| 1 5/16 | 43.6 | 58.2 | 72.8 | 87.3 | 102. | 116. | 131. | 146. | 160 | 175 | 189 | 204 | 218 | 233 | 247 |
| 1 3/8 | 41.7 | 55.6 | 69.5 | 83.3 | 97.2 | 111. | 125. | 139. | 153 | 167 | 180 | 195 | 208 | 222 | 236 |
| 1 7/16 | 39.8 | 53.0 | 66.3 | 79.5 | 92.8 | 106. | 119. | 133. | 146 | 159 | 172 | 186 | 199 | 212 | 225 |
| 1 1/2 | 38.2 | 50.8 | 63.7 | 76.3 | 89.2 | 102. | 115. | 127. | 140 | 153 | 165 | 178 | 191 | 204 | 216 |
| 1 9/16 | 36.6 | 48.8 | 61.0 | 73.2 | 85.4 | 97.6 | 110. | 122. | 134 | 146 | 159 | 171 | 183 | 195 | 207 |
| 1 5/8 | 35.0 | 47.0 | 58.8 | 70.5 | 82.2 | 93.9 | 106. | 117. | 129 | 141 | 152 | 165 | 176 | 188 | 199 |
| 1 11/16 | 33.9 | 45.2 | 56.5 | 67.8 | 79.1 | 90.4 | 102. | 113. | 124 | 136 | 147 | 158 | 170 | 181 | 192 |
| 1 3/4 | 32.7 | 43.6 | 54.5 | 65.5 | 76.4 | 87.3 | 98.2 | 109. | 120 | 131 | 142 | 153 | 164 | 175 | 185 |
| 1 13/16 | 31.7 | 42.2 | 52.8 | 63.3 | 73.9 | 84.4 | 95.0 | 106. | 116 | 127 | 137 | 148 | 158 | 169 | 179 |
| 1 7/8 | 30.6 | 40.7 | 50.9 | 61.1 | 71.3 | 81.5 | 91.9 | 102. | 112 | 122 | 133 | 143 | 153 | 163 | 173 |
| 1 15/16 | 29.6 | 39.4 | 49.3 | 59.1 | 69.0 | 78.8 | 88.7 | 98.5 | 108 | 118 | 128 | 138 | 148 | 158 | 167 |
| 2 | 28.7 | 38.2 | 47.8 | 57.3 | 66.9 | 76.4 | 86.0 | 95.5 | 105 | 115 | 124 | 134 | 143 | 153 | 162 |

| Diam., Inches | FEET PER MINUTE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 90 | 95 | 100 | 110 | 120 | 125 | 130 | 140 | 150 | 160 | 170 | 175 | 180 | 190 | 200 |
| | Revolutions per Minute | | | | | | | | | | | | | | |
| 1/16 | 5502 | 5808 | 6114 | 6725 | 7337 | 7643 | 7948 | 8560 | 9171 | 9782 | .... | .... | .... | .... | .... |
| 1/8 | 2750 | 2903 | 3056 | 3362 | 3667 | 3820 | 3973 | 4278 | 4584 | 4890 | 5195 | 5348 | 5501 | 5806 | 6112 |
| 3/16 | 1834 | 1936 | 2038 | 2242 | 2446 | 2548 | 2649 | 2853 | 2157 | 3261 | 3465 | 5367 | 3668 | 3872 | 4076 |
| 1/4 | 1376 | 1453 | 1528 | 1681 | 1734 | 1910 | 1986 | 2139 | 2292 | 2445 | 2598 | 2674 | 2750 | 2903 | 3056 |
| 5/16 | 1100 | 1161 | 1222 | 1344 | 1466 | 1527 | 1589 | 1711 | 1833 | 1955 | 2077 | 2139 | 2200 | 2322 | 2444 |
| 3/8 | 916 | 967 | 1018 | 1121 | 1222 | 1273 | 1323 | 1425 | 1527 | 1629 | 1731 | 1782 | 1832 | 1934 | 2036 |
| 7/16 | 786 | 830 | 874 | 961 | 1049 | 1093 | 1136 | 1224 | 1311 | 1398 | 1486 | 1530 | 1573 | 1661 | 1748 |
| 1/2 | 688 | 726 | 764 | 840 | 917 | 955 | 993 | 1070 | 1146 | 1222 | 1299 | 1337 | 1375 | 1452 | 1528 |
| 9/16 | 611 | 645 | 679 | 747 | 813 | 869 | 883 | 951 | 1019 | 1086 | 1154 | 1188 | 1222 | 1290 | 1358 |
| 5/8 | 552 | 581 | 612 | 673 | 736 | 765 | 796 | 857 | 918 | 979 | 1040 | 1071 | 1102 | 1163 | 1224 |
| 11/16 | 500 | 527 | 555 | 611 | 666 | 692 | 722 | 770 | 833 | 888 | 944 | 971 | 999 | 1054 | 1110 |
| 3/4 | 458 | 483 | 508 | 559 | 610 | 635 | 661 | 711 | 762 | 813 | 864 | 889 | 914 | 965 | 1016 |
| 13/16 | 427 | 450 | 474 | 521 | 569 | 593 | 616 | 664 | 711 | 758 | 806 | 830 | 853 | 901 | 948 |
| 7/8 | 392 | 416 | 438 | 482 | 526 | 548 | 569 | 613 | 657 | 701 | 745 | 767 | 788 | 832 | 876 |
| 15/16 | 366 | 387 | 407 | 448 | 488 | 509 | 529 | 570 | 611 | 651 | 692 | 712 | 733 | 773 | 814 |
| 1 | 344 | 363 | 382 | 420 | 458 | 478 | 497 | 535 | 573 | 611 | 649 | 669 | 688 | 726 | 764 |
| 1 1/16 | 323 | 341 | 359 | 395 | 431 | 449 | 467 | 503 | 539 | 579 | 610 | 628 | 646 | 682 | 718 |
| 1 1/8 | 306 | 324 | 340 | 374 | 408 | 425 | 442 | 476 | 510 | 544 | 578 | 595 | 612 | 646 | 680 |
| 1 3/16 | 290 | 306 | 322 | 354 | 386 | 403 | 419 | 451 | 483 | 515 | 547 | 564 | 580 | 612 | 644 |
| 1 1/4 | 274 | 291 | 306 | 337 | 367 | 383 | 398 | 428 | 459 | 490 | 520 | 536 | 551 | 581 | 612 |
| 1 5/16 | 262 | 276 | 291 | 320 | 349 | 351 | 378 | 407 | 437 | 466 | 495 | 509 | 524 | 553 | 582 |
| 1 3/8 | 250 | 264 | 278 | 306 | 334 | 348 | 361 | 389 | 417 | 445 | 472 | 487 | 500 | 528 | 556 |
| 1 7/16 | 239 | 272 | 265 | 292 | 318 | 331 | 345 | 371 | 398 | 424 | 451 | 464 | 477 | 504 | 530 |
| 1 1/2 | 230 | 241 | 254 | 279 | 305 | 318 | 330 | 356 | 381 | 406 | 432 | 445 | 457 | 483 | 508 |
| 1 9/16 | 220 | 232 | 244 | 268 | 293 | 305 | 317 | 342 | 366 | 390 | 415 | 427 | 439 | 464 | 488 |
| 1 5/8 | 212 | 222 | 234 | 257 | 281 | 293 | 304 | 328 | 351 | 374 | 398 | 410 | 421 | 445 | 468 |
| 1 11/16 | 203 | 215 | 226 | 249 | 271 | 283 | 294 | 316 | 339 | 362 | 384 | 396 | 407 | 429 | 452 |
| 1 3/4 | 196 | 207 | 218 | 240 | 262 | 273 | 283 | 305 | 327 | 349 | 371 | 382 | 392 | 414 | 436 |
| 1 13/16 | 190 | 200 | 211 | 232 | 253 | 264 | 274 | 295 | 317 | 338 | 359 | 369 | 380 | 401 | 422 |
| 1 7/8 | 184 | 194 | 204 | 224 | 244 | 255 | 265 | 286 | 306 | 326 | 347 | 357 | 367 | 388 | 408 |
| 1 15/16 | 177 | 187 | 197 | 217 | 236 | 246 | 256 | 276 | 296 | 315 | 335 | 345 | 355 | 374 | 394 |
| 2 | 172 | 181 | 191 | 210 | 229 | 239 | 248 | 267 | 287 | 306 | 325 | 334 | 344 | 363 | 382 |

*Machinery*

Starting with any of the preceding speeds and feeds which have been recommended by different authorities, the operator carefully notes the condition of the drill after it has been working for some time. If the drill shows a tendency to wear away on the outside, it is running too fast, while if it breaks or chips on the cutting edges, the feed is probably too heavy for the job. A little careful experimenting in this way, making changes gradually according to indications which are shown after working for some time, will usually result in hitting upon a combination of speed and feed which will be the means of securing something approaching the maximum possible production. It will, of course, be obvious that to obtain a given peripheral cutting speed, the number of revolutions per minute must differ according to the size of the drill which is being used. This is the reason for running very small drills at extremely high speeds in order to have them working under conditions which approximate the required cutting speed for the material that is being machined. For the convenience of users of twist drills and other rotary cutting tools, tables are available which show the number of revolutions per minute at which a given size of drill should be run in order to obtain the required cutting speed. In Table 1 it will be seen that the diameters of drills are given in the left-hand column, while peripheral cutting speeds in feet per minute are noted at the top of the table. By finding the intersection of horizontal and vertical lines through the given drill diameter and the required cutting speed, we find the number of revolutions per minute at which the drill must be run in order to obtain this speed. Table 2 gives the decimal equivalents of nominal sizes of drills, and will be found useful when calculating the peripheral cutting speed of drills of various sizes; this table also shows the relation of the different sizes of drills, which are designated by letters and numbers, as compared to the fractional sized drills.

TABLE 2. DECIMAL EQUIVALENTS OF NOMINAL SIZES OF DRILLS

| Inch | Wire Gage | Decimals of an Inch | Inch | Wire Gage | Decimals of an Inch | Inch | Wire Gage | Decimals of an Inch | Inch | Letter Sizes | Decimals of an Inch | Inch | Decimals of an Inch | Inch | Decimals of an Inch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 80 | 0.0135 | | 44 | 0.0860 | | 10 | 0.1935 | | T | 0.3580 | 7/8 | 0.8750 | 1 33/64 | 1.5156 |
| | 79 | 0.0145 | | 43 | 0.0890 | | 9 | 0.1960 | 23/64 | | 0.3594 | 57/64 | 0.8906 | 1 17/32 | 1.5313 |
| 1/64 | | 0.0156 | | 42 | 0.0935 | | 8 | 0.1990 | | U | 0.3680 | 29/32 | 0.9063 | 1 35/64 | 1.5469 |
| | 78 | 0.0160 | 3/32 | | 0.0938 | | 7 | 0.2010 | 3/8 | | 0.3750 | 59/64 | 0.9219 | 1 9/16 | 1.5625 |
| | 77 | 0.0180 | | 41 | 0.0960 | 13/64 | | 0.2031 | | V | 0.3770 | 15/16 | 0.9375 | 1 37/64 | 1.5781 |
| | 76 | 0.0200 | | 40 | 0.0980 | | 6 | 0.2040 | | | 0.3819 | 61/64 | 0.9531 | 1 19/32 | 1.5938 |
| | 75 | 0.0210 | | 39 | 0.0995 | | 5 | 0.2055 | | W | 0.3860 | 31/32 | 0.9688 | 1 39/64 | 1.6094 |
| | 74 | 0.0225 | | 38 | 0.1015 | | 4 | 0.2090 | 25/64 | | 0.3906 | 63/64 | 0.9844 | 1 5/8 | 1.6250 |
| | 73 | 0.0240 | | 37 | 0.1040 | | 3 | 0.2130 | | X | 0.3970 | 1 | 1.0000 | 1 41/64 | 1.6406 |
| | 72 | 0.0250 | | 36 | 0.1065 | 7/32 | | 0.2188 | | Y | 0.4040 | 1 1/64 | 1.0156 | 1 21/32 | 1.6563 |
| | 71 | 0.0260 | 7/64 | | 0.1094 | | 2 | 0.2210 | 13/32 | | 0.4063 | 1 1/32 | 1.0313 | 1 43/64 | 1.6719 |
| | 70 | 0.0280 | | 35 | 0.1100 | | 1 | 0.2280 | | Z | 0.4130 | 1 3/64 | 1.0469 | 1 11/16 | 1.6875 |
| | 69 | 0.0293 | | 34 | 0.1110 | | | | 27/64 | | 0.4219 | 1 1/16 | 1.0625 | 1 45/64 | 1.7031 |
| | 68 | 0.0310 | | 33 | 0.1130 | | Letter Sizes | | 7/16 | | 0.4375 | 1 5/64 | 1.0781 | 1 23/32 | 1.7188 |
| 1/32 | | 0.0313 | | 32 | 0.1160 | | | | 29/64 | | 0.4531 | 1 3/32 | 1.0938 | 1 47/64 | 1.7344 |
| | 67 | 0.0320 | | 31 | 0.1200 | | A | 0.2340 | 15/32 | | 0.4688 | 1 7/64 | 1.1094 | 1 3/4 | 1.7500 |
| | 66 | 0.0330 | 1/8 | | 0.1250 | 15/64 | | 0.2344 | 31/64 | | 0.4844 | 1 1/8 | 1.1250 | 1 49/64 | 1.7656 |
| | 65 | 0.0350 | | 30 | 0.1285 | | B | 0.2380 | 1/2 | | 0.5000 | 1 9/64 | 1.1406 | 1 25/32 | 1.7813 |
| | 64 | 0.0360 | | 29 | 0.1360 | | C | 0.2420 | 33/64 | | 0.5156 | 1 5/32 | 1.1563 | 1 51/64 | 1.7969 |
| | 63 | 0.0370 | | 28 | 0.1405 | | D | 0.2460 | 17/32 | | 0.5313 | 1 11/64 | 1.1719 | 1 13/16 | 1.8125 |
| | 62 | 0.0380 | 9/64 | | 0.1406 | 1/4 | E | 0.2500 | 35/64 | | 0.5469 | 1 3/16 | 1.1875 | 1 53/64 | 1.8281 |
| | 61 | 0.0390 | | 27 | 0.1440 | | F | 0.2570 | 9/16 | | 0.5625 | 1 13/64 | 1.2031 | 1 27/32 | 1.8438 |
| | 60 | 0.0400 | | 26 | 0.1470 | | G | 0.2610 | 37/64 | | 0.5781 | 1 7/32 | 1.2188 | 1 55/64 | 1.8594 |
| | 59 | 0.0410 | | 25 | 0.1495 | 17/64 | | 0.2656 | 19/32 | | 0.5938 | 1 15/64 | 1.2344 | 1 7/8 | 1.8750 |
| | 58 | 0.0420 | | 24 | 0.1520 | | H | 0.2660 | 39/64 | | 0.6094 | 1 1/4 | 1.2500 | 1 57/64 | 1.8906 |
| | 57 | 0.0430 | | 23 | 0.1540 | | I | 0.2720 | 5/8 | | 0.6250 | 1 17/64 | 1.2656 | 1 29/32 | 1.9063 |
| | 56 | 0.0465 | 5/32 | | 0.1563 | | J | 0.2770 | 41/64 | | 0.6406 | 1 9/32 | 1.2813 | 1 59/64 | 1.9219 |
| 3/64 | | 0.0469 | | 22 | 0.1570 | | K | 0.2810 | 21/32 | | 0.6563 | 1 19/64 | 1.2969 | 1 15/16 | 1.9375 |
| | 55 | 0.0520 | | 21 | 0.1590 | 9/32 | | 0.2813 | 43/64 | | 0.6719 | 1 5/16 | 1.3125 | 1 61/64 | 1.9531 |
| | 54 | 0.0550 | | 20 | 0.1610 | | L | 0.2900 | 11/16 | | 0.6875 | 1 21/64 | 1.3281 | 1 31/32 | 1.9688 |
| | 53 | 0.0595 | | 19 | 0.1660 | | M | 0.2950 | 45/64 | | 0.7031 | 1 11/32 | 1.3438 | 1 63/64 | 1.9844 |
| 1/16 | | 0.0625 | | 18 | 0.1695 | 19/64 | | 0.2969 | 23/32 | | 0.7188 | 1 23/64 | 1.3594 | 2 | 2.0000 |
| | 52 | 0.0635 | 11/64 | | 0.1719 | | N | 0.3020 | 47/64 | | 0.7344 | 1 3/8 | 1.3750 | 2 1/64 | 2.0156 |
| | 51 | 0.0670 | | 17 | 0.1730 | 5/16 | | 0.3125 | 3/4 | | 0.7500 | 1 25/64 | 1.3906 | 2 1/32 | 2.0313 |
| | 50 | 0.0700 | | 16 | 0.1770 | | O | 0.3160 | 49/64 | | 0.7656 | 1 13/32 | 1.4063 | 2 3/64 | 2.0469 |
| | 49 | 0.0730 | | 15 | 0.1800 | | P | 0.3230 | 25/32 | | 0.7813 | 1 27/64 | 1.4219 | 2 1/16 | 2.0625 |
| | 48 | 0.0760 | | 14 | 0.1820 | 21/64 | | 0.3281 | 51/64 | | 0.7969 | 1 7/16 | 1.4375 | 2 5/64 | 2.0781 |
| 5/64 | | 0.0781 | | 13 | 0.1850 | | Q | 0.3320 | 13/16 | | 0.8125 | 1 29/64 | 1.4531 | 2 3/32 | 2.0938 |
| | 47 | 0.0785 | 3/16 | | 0.1875 | | R | 0.3390 | 53/64 | | 0.8281 | 1 15/32 | 1.4688 | | |
| | 46 | 0.0810 | | 12 | 0.1890 | 11/32 | | 0.3438 | 27/32 | | 0.8438 | 1 31/64 | 1.4844 | | |
| | 45 | 0.0820 | | 11 | 0.1910 | | S | 0.3480 | 55/64 | | 0.8594 | 1 1/2 | 1.5000 | | |

*Machinery*

### Variable-speed Drive for Drilling Machine

Where quick-change chucks are used to facilitate changing tools for the performance of a sequence of operations on a piece of work, it is apparent that provision must be made for changing the spindle speed of the drilling machine for different sizes of tools, or else some of these tools will have to be driven below the most efficient speeds for such sizes of drills, counterbores, etc. In Fig. 1 is shown a radial drilling machine equipped with variable-speed motor drive and means of automatically changing the speed so that approximately the proper speed may be obtained for each size of tool that is used. The machine is shown at work in the shops of the Universal Motor Co., and the automatic speed-changing device was designed by L. J. Monahan, president of the firm, who has applied for a patent on this idea. Referring to Fig. 2, it will be seen that the drilling machine is equipped with one of the "Magic" chucks *A* made by the Modern Tool Co., and the collets *B* which enter this chuck are each provided with a pin *C* which extends up through the chuck body and engages the bottom of pin *D*. These pins *C* are made of different lengths and automatically adjust a speed-controlling rheostat *E* to provide for regulating the speed of motor *F* to give the proper spindle speed for the particular size of drill or other tool being used. In this way there is assurance of each tool being driven at its most efficient speed. By making the speed change automatically, no demand is made upon the operator, and so there is no loss of time in speed changing; also the "Magic" chuck enables tools to be changed without stopping the rotation of the drilling machine spindle.

### Critical Drilling Speeds

In experimenting to determine the number of revolutions per minute at which a drill will have the greatest productive capacity, some interesting results are secured. Researches which were made at the plant of Baker Bros., with the view of securing data required in connection with the design of their drilling machines, showed that there are certain critical speeds at which a twist drill will have a satisfactory rate of production, while there are other speeds—often lying between two rates of speed where the production is satisfactory—at which the drill will fail to give anything approaching satisfactory results. This condition is clearly shown by Fig. 3, which is plotted with data taken from the original tests in the Baker Bros. plant; in this connection the reader's attention is called to the fact that these investigations were made several years ago, so that, while the condition shown by this set of curves is an established fact, the rates of speed and feed are lower than would be used in conducting similar tests at the present time. The point brought out by this diagram is the remarkable increase in production which can be secured by increasing the speed. The curves are plotted for the maxi-

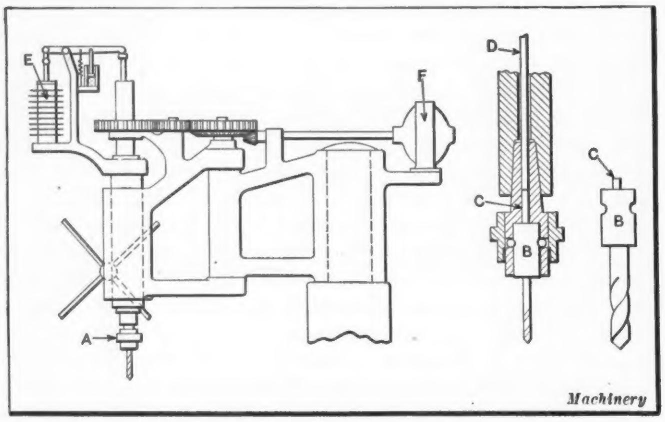



Fig. 2. Method of obtaining Automatic Control of Variable-speed Motor Drive

mum feed at which the stock was successfully drilled without destroying the drill; at the next higher feed the drill would be destroyed. Curve No. 2 shows that the drill would give a far greater production without failing at 200 R.P.M. than it would at 250 R.P.M., and also that it would give a much greater production if the speed were still further increased to 400 R.P.M.

This is of particular interest in connection with the suggestions made for experimenting to determine the speed at which a given drilling operation may be performed to secure the greatest possible output. Should it happen that the drilling machine operator has reason to believe that the speed he is using is too low, but finds that a moderate increase in speed results in an even less satisfactory rate of production, he is justified in believing that if the speed rate of penetration were plotted in the form of a curve shown in Fig. 3, the "speed-penetration" curve has taken one of those peculiar dips exhibited in this illustration, and that at a still further increase in speed will probably result in determining a rate at which the desired production will be attained. If such is the case, it is obvious that correction of the original cause for the unsatisfactory rate of production will be made by a considerable increase in speed and not by making a reduction in speed, as might be inferred from the fact that advancing a little from the original speed at which production was unsatisfactory showed that even less desirable results were being obtained.

Recently a well-known manufacturing establishment had an investigating committee working for over two years on the development of a table of speeds and feeds for use in connection with different sizes of drills working in various materials. The result of this investigation is presented in Tables 3 and 4, and although it is not claimed that the data presented can be followed without modification, it is claimed that the thousands of tests which were made during the period over which these data were secured have led to results which may safely be regarded as an average maximum of the rate of speed and feed under which a drilling machine may be operated. These tables are copyrighted by the Henry & Wright Mfg. Co., and the tests were made on a special drilling machine built by this company.

In starting to work on a new job the operator of the drilling machine will use the speed and feed shown in this table, but should he find that the drill shows a tendency to wear around its periphery or that there is a considerable amount of chipping along the cutting edges of the drill, it indicates that the speed or feed is too heavy, and so the required adjustment of operating conditions must be made. In the plant where these data were obtained, the investigating committee reported that the installation of machines capable of operating under these conditions of speed and feed would represent a saving of $30,000 a year. The speeds recommended are rather high, and if twist drills are unable to stand them, the drill manufacturers should be notified, as it is claimed that any responsible maker can furnish suitable drills for use under these conditions, if he is required to do so. The speeds are also too high for machines equipped with plain bearings, but properly constructed machines with ball bearings will easily stand up under such conditions of operations.

After reading the preceding suggestions concerning the most efficient speeds and feeds at which drilling operations can be performed, the reader will naturally be impressed by the difference in these recommendations, and noting that they are made by men who have equal opportunities of determining the required information, he will ask himself which conditions are likely to produce the best results in his own shop. The difference in these recommendations is probably due to the fact that there are so many variables which enter into the performance of drilling operations that different combinations of variable conditions enable the most satisfactory results to be obtained when using speeds and feeds which differ substantially. Regardless of the reason, it is a matter of fact that different men have found that the most satisfactory results are obtained when running their drilling machines under conditions of speed and feed which differ substantially when drilling a given size of hole in the same material. Such being the case, the best advice which can be given to the man who is trying to improve conditions in his drilling department is to adopt the method of experimenting with trial speeds and feeds—adopting those trial speeds and feeds recommended in the preceding discussion—until he has found the conditions of speed and feed which give the most satisfactory results on his work.

### Advantages of Drilling at High Speed

Machine tool builders are now making drilling machines fully equipped with ball bearings so that they are adapted for operation at speeds which would have been utterly impossible of attainment a few years ago. For instance, the Leland-Gifford Co. builds a machine which is adapted for operation at speeds of from 11,000 to 15,000 revolutions per minute, and the same speeds are recommended for use on a bench drilling machine recently brought out by the Fenn Mfg. Co. Other machinery builders are making high-speed drilling machines. Driving twist drills at such speeds means that the drilling operation is practically instantaneous; in fact, the speed at which holes may be drilled is often equal, if not in excess, of the speed at which the same work could be done on a power press. It is this constant increase in the speed of drilling, with the constant reduction of the ratio between "drilling time" and "setting-up time," which has emphasized the fact that, in order to approach the maximum rate of production,

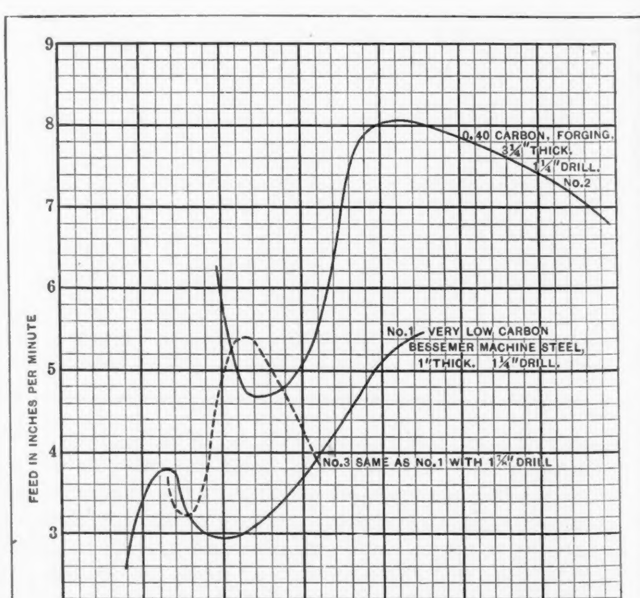



Fig. 3. Diagram showing Effect of Critical Speeds on Penetration-speed Curves

TABLE 3. SPEEDS AND FEEDS FOR HIGH-SPEED DRILLS WORKING IN VARIOUS METALS

| Size of Drill, Inch | Feed per Rev., Inch | Bronze, Brass, 300 Feet, R.P.M. | Cast Iron, Annealed, 170 Feet, R.P.M. | Hard Cast Iron, 80 Feet R.P.M. | Mild Steel, 120 Feet, R.P.M. | Drop-forging 60 Feet, R.P.M. | Malleable Iron, 90 Feet, R.P.M. | Tool Steel, 60 Feet, R.P.M. | Cast Steel, 40 Feet, R.P.M. |
|---|---|---|---|---|---|---|---|---|---|
| 1/16 | 0.003 | .... | .... | 4880 | .... | 3660 | .... | 3660 | 2440 |
| 1/8 | 0.004 | .... | 5185 | 2440 | 3660 | 1830 | 2745 | 1830 | 1220 |
| 3/16 | 0.005 | .... | 3456 | 1626 | 2440 | 1210 | 1830 | 1220 | 807 |
| 1/4 | 0.006 | 4575 | 2593 | 1220 | 1830 | 915 | 1375 | 915 | 610 |
| 5/16 | 0.007 | 3660 | 2074 | 976 | 1464 | 732 | 1138 | 732 | 490 |
| 3/8 | 0.008 | 3050 | 1728 | 813 | 1220 | 610 | 915 | 610 | 407 |
| 7/16 | 0.009 | 2614 | 1482 | 698 | 1046 | 522 | 784 | 522 | 348 |
| 1/2 | 0.010 | 2287 | 1296 | 610 | 915 | 458 | 636 | 458 | 305 |
| 5/8 | 0.011 | 1830 | 1037 | 488 | 732 | 366 | 569 | 366 | 245 |
| 3/4 | 0.012 | 1525 | 864 | 407 | 610 | 305 | 458 | 305 | 203 |
| 7/8 | 0.013 | 1307 | 741 | 349 | 523 | 261 | 392 | 261 | 174 |
| 1 | 0.014 | 1143 | 648 | 305 | 458 | 229 | 349 | 229 | 153 |
| 1 1/4 | 0.016 | 915 | 519 | 244 | 366 | 183 | 275 | 183 | 122 |
| 1 1/2 | 0.016 | 762 | 432 | 204 | 305 | 153 | 212 | 153 | 102 |
| 1 3/4 | 0.016 | 654 | 371 | 175 | 262 | 131 | 196 | 131 | 87 |
| 2 | 0.016 | 571 | 323 | 153 | 229 | 115 | 172 | 115 | 77 |

*Machinery*

the user of high-speed drilling machines must design his work-holding fixtures in such a way that work may either be set up in indexing fixtures while the drilling operation is being performed, or, if this is not feasible, the clamping devices on fixtures must be so constructed that a minimum amount of time is consumed in securing the work in place ready to be drilled.

Several important advantages are secured through drilling at high speed, and this is particularly the case with small sized drills, which are likely to break, and also with high-speed steel drills. The reasons for this are as follows: In the case of small drills operated in sensitive drilling machines equipped with hand feed, running the drill at high speed makes it improbable that the operator will impose an excessive feed on the drill, because, in the case of a drill which is running at from 10,000 to 15,000 revolutions per minute, it would be necessary to pull the feed lever down extremely fast in order that the feed for any one revolution of the drill would be sufficient to impose a stress in the steel which would be in excess of the maximum that the strength of the drill is capable of withstanding. A further explanation for the increased strength of a drill when running at high speed is that where an excessive amount of feed pressure tends to bend the drill slightly when running at high speed, the length of time that any set of fibers in the drill is subjected to stress is so short that the danger of breaking may be less than if the load remains on such fibers for a greater length of time. This is, of course, a moot question and is advanced in the form of a hypothesis rather than a statement of fact; in any case, the question is an interesting one.

TABLE 4. SPEEDS AND FEEDS FOR CARBON STEEL DRILLS WORKING IN VARIOUS METALS

| Size of Drill, Inch | Feed per Rev., Inch | Bronze, Brass, 200 Feet, R.P.M. | Cast Iron, Annealed, 85 Feet, R.P.M. | Hard Cast Iron, 40 Feet, R.P.M. | Mild Steel, 60 Feet, R.P.M. | Drop-forging 30 Feet, R.P.M. | Malleable Iron, 45 Feet, R.P.M. | Tool Steel, 30 Feet, R.P.M. | Cast Steel, 20 Feet, R.P.M. |
|---|---|---|---|---|---|---|---|---|---|
| 1/16 | 0.003 | .... | 5185 | 2440 | 3660 | 1830 | 2745 | 1830 | 1220 |
| 1/8 | 0.004 | 4575 | 2593 | 1220 | 1830 | 915 | 1375 | 915 | 610 |
| 3/16 | 0.005 | 3050 | 1728 | 813 | 1220 | 610 | 915 | 610 | 407 |
| 1/4 | 0.006 | 2287 | 1296 | 610 | 915 | 458 | 636 | 458 | 305 |
| 5/16 | 0.007 | 1830 | 1037 | 488 | 732 | 366 | 569 | 366 | 245 |
| 3/8 | 0.008 | 1525 | 864 | 407 | 610 | 305 | 458 | 305 | 203 |
| 7/16 | 0.009 | 1307 | 741 | 349 | 523 | 261 | 392 | 261 | 174 |
| 1/2 | 0.010 | 1143 | 648 | 305 | 458 | 229 | 343 | 229 | 153 |
| 5/8 | 0.011 | 915 | 519 | 244 | 366 | 183 | 275 | 183 | 122 |
| 3/4 | 0.012 | 762 | 432 | 204 | 305 | 153 | 212 | 153 | 102 |
| 7/8 | 0.013 | 654 | 371 | 175 | 262 | 131 | 196 | 131 | 87 |
| 1 | 0.014 | 571 | 323 | 153 | 229 | 115 | 172 | 115 | 77 |
| 1 1/4 | 0.016 | 458 | 260 | 122 | 183 | 92 | 138 | 92 | 61 |
| 1 1/2 | 0.016 | 381 | 216 | 102 | 153 | 77 | 106 | 77 | 51 |
| 1 3/4 | 0.016 | 327 | 186 | 88 | 131 | 66 | 98 | 66 | 44 |
| 2 | 0.016 | 286 | 162 | 87 | 115 | 58 | 86 | 58 | 39 |

*Machinery*

With high-speed steel drills, there is an increase in strength and durability when running at high speed which can be explained in a more definite way. At a speed of, say, 10,000 R.P.M., the frictional resistance and tendency for the drill to become heated is far more pronounced than where the drill is being operated at, say, 350 R.P.M. It is a well-known fact that many classes of high-speed steel are tough and hard even at temperatures corresponding to a dull red heat; conversely, such steels are inclined to be quite brittle at low temperatures. As a result, the increase in frictional resistance resulting from the operation of a high-speed steel drill at the higher speed results in increasing its temperature, with a corresponding improvement in the toughness and hardness of the steel. Consequently it is obvious that a high-speed steel drill should give better results when working at speeds which cause it to become heated slightly while in operation.

This naturally leads to two points which should be observed in caring for high-speed steel drills in order to enable them to give the best possible results. In cold weather it will be found advantageous to warm the drills slightly before they are placed in service. Such an increase in temperature will

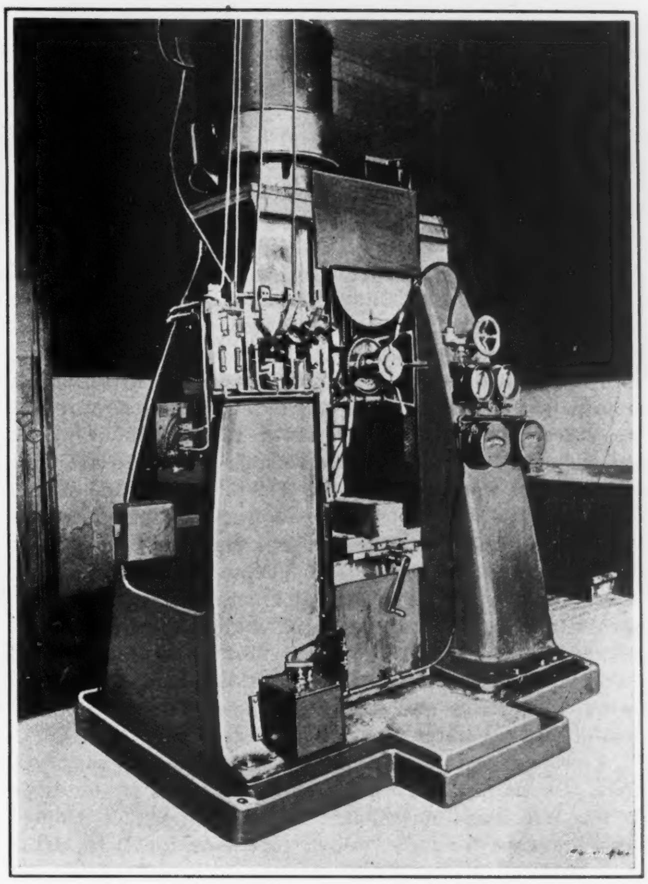


Fig. 4. Special Drilling Machine used in Laboratory of Standard Tool Co.

be the means of taking much of the brittleness out of the metal, thus avoiding danger of the drill breaking before it has had time to become warmed up through frictional resistance between the tool and work which is being drilled. Another point which is sufficiently important to merit careful consideration is that some makes of high-speed steel are likely to be damaged if suddenly quenched in cold water. In grinding a drill, some operators will plunge the point into water, and when this is done there is danger of introducing cracks in the cutting edge; these may not be of sufficient magnitude to show to the naked eye, but when the drill is put to work trouble is likely to be experienced at once through the chipping away of steel along the lips of the drill.

### Investigation of Feed Pressure Required for Drilling

In Fig. 4 there is shown a special drilling machine which was built for use in the laboratory of the Standard Tool Co. for conducting experimental work on twist drills. It will be seen that this machine is symmetrically designed on both sides of an axis corresponding to the axis of the twist drill which

is being tested, this arrangement tending to equalize all stresses that are set up in the frame of the machine and to cause the thrust of the drill to be vertically downward. In the case of an ordinary drilling machine with the overhanging type of frame, there is a cantilever action which causes the thrust of the drill to be separated into two components. On this special drilling machine shown in Fig. 4, the bedplate which supports the work rests on a 12-inch piston, which is ground to a sliding fit in a cylinder filled with oil. Arms and counterweights attached to each side of the piston compensate for the total weight of the piston and bedplate, so that gages connected to the oil cylinder indicate the pressure actually applied by the drill, the gages being calibrated to indicate the total pressure on the 12-inch ram. Two gages are used, one of which reads up to 3000 pounds, while the other reads up to 15 tons.

The spindle and feed mechanisms are driven by two independent electric motors. For driving the spindle, the motor is mounted at the top of the machine with the armature shaft in a vertical position, so that it may be direct-connected to the spindle of the drilling machine. The feed mechanism is driven by a motor located at the right-hand side of the machine, and this motor is connected to the feed through a system of worm-gears and a rack and pinion. An indicating wattmeter in each circuit shows the power consumption, and each motor is furnished with an independent rheostat by which variations in speed are effected. The speeds of the motors that drive the spindle and feed mechanism are indicated by two Warner tachometers, and a chart has been developed to give the rate of feed for different speeds of the motor that drives the feed mechanism.

A series of tests was conducted on this machine by Paul Bedell Starr and John Millard Marsh to secure data for a thesis presented at the time these men took the degree of Bachelor of Science in mechanical engineering at the Case School of Applied Science. The object of this investigation was principally to determine the feed pressure required to drive different sizes of drills under various conditions of speed and feed. That very little reliable data were available on this subject was shown by the fact that, when the special drilling machine was first built by a firm of wide experience in the design and construction of equipment of this type, a pressure gage reading up to 3000 pounds was provided. At the first test, using a 1-inch drill at a normal rate of feed, the range of this gage was shown to be entirely inadequate, and so a gage reading up to 15 tons was substituted, which proved suitable for the service required of it, this difference in gages showing conclusively that the knowledge concerning the magnitude of feed pressures was not at all definite.

Five series of tests were conducted under the following conditions: On the first series, the clearance angle of the drills used was less than the standard 12-degree clearance adopted by the Standard Tool Co., which furnished the twist drills used in making this investigation. On the second series, the clearance angle was greater than the standard 12 degrees. On the third series, the drills used were standard in every respect. On the fourth series, the web thickness of the drills was 10 per cent under standard, and thinned in accordance with the practice of the Standard Tool Co. On the fifth series, the web thickness was 10 per cent above standard. The first series of tests, with the clearance angle less than the standard of 12 degrees, showed that an excessive amount of feed pressure was required to operate a drill ground in this way, such a result being entirely expected, because the cutting edges are not given free play. In the second and third series of tests, where the clearance angle was greater than the standard of 12 degrees, and where all dimensions of the drills were standard, practically the same results were obtained as regards feed pressure, which indicated that no particular advantage was obtained by increasing the clearance angle beyond 12 degrees. It will also be recalled that such an increase results in weakening the cutting edges of the drill and introducing a tendency for them to be damaged by chipping.

In the fourth series of tests, where the web thickness was reduced 10 per cent, there was a noticeable decrease in feed pressure, which indicates that advantages are to be secured through thinning the point of the drill, provided this work is carefully done, so that there is no danger of weakening the drill sufficiently to cause it to split up the center. For the fifth series of tests, where the web thickness was greater than standard, the results obtained were not entirely satisfactory, but, under these conditions of operation, it is fairly safe to assume that an increase in feed pressure would be the result. The data secured from these tests must be regarded more in the light of indications of probable results from varying conditions of operation than as statements of fact concerning results actually discovered, because lack of time made it impossible for Mr. Starr and Mr. Marsh to carry their investigations far enough to secure average results; and average results are particularly important in the case of drilling tests, because of the numerous variations which may affect results.

#### Power Required to Drive Drilling Machines

The Detroit Twist Drill Co. states that the efficiency of most drilling machines is from 10 to 20 per cent, *i.e.*, there is seldom over one-fifth of the power used to drive a drilling machine which is transmitted to the drill point. It frequently happens that very little care is taken to see that drilling machine bearings are properly aligned and lubricated, and this is especially true in the case of ball thrust bearings, which must be kept in good working condition in order to be effective in helping the machine to give the maximum possible service. Attention to the upkeep of machine bearings is exceptionally important in the case of drilling machines operated at excessively high speed.

#### Coolants and Lubricants Used for Drilling

For drilling operations, satisfactory results can usually be obtained through the use of one of the soluble oil coolants, for all classes of work where the length of chips produced is not very great; but in cases where long chips are formed, there is a rubbing action produced by the chips sliding over the lips of the drill, which produces a condition analogous to that of a machine bearing, thus making it necessary to apply a fluid which serves the combined purpose of lubricant and coolant. The following is an outline of lubricants and coolants recommended for drilling operations in various classes of material, and the lubricants used are recommended in the order in which they are named. In this list "cutting compound" refers to any satisfactory brand of soluble oil mixed with water, in accordance with the manufacturer's instructions; and "mineral lard oil" is a mixture of lard oil and light petroleum oil. The proportions of this mixture vary according to the work, but one part of lard oil to two parts of petroleum gives a mixture that is well suited to the requirements of many average drilling operations. For drilling high-carbon or alloy steel, use mineral lard oil or turpentine; low-carbon steel, mineral lard oil or cutting compound; cast iron, dry or compressed air; wrought iron, cutting compound or mineral lard oil; malleable iron, cutting compound; brass, dry; bronze, cutting compound or dry; copper, mineral lard oil; aluminum, kerosene, beeswax, or tallow; monel metal, cutting compound; and glass, solution of camphor in turpentine.

* * *

## QUENCHING LIQUIDS

The quenching of a piece of steel is most important. The quenching liquid should cool the piece readily without being so harsh as to cause a rupture of the fibers. When hot steel is continually dumped into a tank of oil, the lighter and volatile oils are evaporated and finally only the heavier oils will be left. When the oil becomes thick, it will not take the heat away from the steel rapidly; consequently the steel will be soft and will not show the maximum physical properties. To obtain such results, the quenching liquid should be of a constant specific gravity and maintained at a temperature of 70 to 90 degrees, but the exact temperature at which the bath is maintained does not matter so much if it is always the same. To insure the best results in manufacturing, the bath should always be maintained at a certain specific gravity and at some certain temperature.—*Proceedings of Steel Treating Research Society of Detroit*

# Pneumatic Riveting Practice

by A. Mason MacFarland[1]

**SHIP RIVETING — DIFFERENT TYPES OF PNEUMATIC RIVETING TOOLS AND MACHINES, THEIR USE, ABUSE, MAINTENANCE AND REPAIR**

THE pressing importance to the country, at the present time, of the machines classed as "pneumatic tools," and the necessity for developing to the greatest degree their efficient use, may be realized from a consideration of these facts: Authorities agree that the greatest immediate need of the war is more ships. A ship may require a million or more rivets to fasten together the plates and frames. In some shipyards it is the practice to ream each hole after the work is assembled, both to remove the material stressed by the punching operation and to align the holes, avoiding later troubles in inserting the hot rivets. Thousands of these holes are so located that it is found more convenient to drill them after the work is assembled than to lay them out for punching previous to assembling. The edges of all of the thousands of plates comprising the shell, bulkheads and tanks of the ship—all the water-tight joints—must be cut to a smooth edge and calked to make a water-tight joint. Under our present conditions, almost all of this work in all the thousands of ships planned and under construction will be done with pneumatic tools.

One of the new yards fitting up to employ 34,000 men is reported to have placed a single order for 6000 pneumatic machines, including riveting and chipping hammers, drilling machines, etc. Several great yards, employing thousands of men on ship repair work, also make extensive use of these tools. For instance, one of the eastern yards employing 1500 men has an equipment of 200 air machines of various kinds, about 50 per cent of which are in more or less constant use. About all the men skilled in the use of these machines which the country can supply are employed, and many who in less busy times would rank as helpers are now drawing pay as skilled men. The additional thousands required to man the new yards and the proposed extensions to the old ones must be made out of raw material. Just how raw this material may be can be realized only by one who has had some experience in the "making" process. It is much easier, however, to teach a man to do this kind of work with a machine than to teach him to do it by the old hand methods.

The numerous riveted joints necessary in ship-work add hundreds of tons to the weight of the ship, due to the overlapping plates, liners, fillers, butt-straps, etc. The way in which the riveting process impresses the uninformed observer was voiced by a fair Vassar graduate who visited the shipyard. After seeing the rivet driving, she was asked what she thought of it: "It seems so foolish," she said, "to make all those little holes and then fill them up again."

Considerable attention has been given to possible ways and means of avoiding this extra labor, but not much progress has been made. The plates have been made larger, thus reducing the number of joints. A system of "jogging" or offsetting the ends of the plates so that a joint may be made without filling pieces is quite extensively used, but no general substitute for rivets on ship-work is yet in sight.

Spot-welding and continuous welding of joints has been developed to a degree where it is practical for light work, and even under some conditions for heavy work, but up to date it has not been considered practical to apply any of these welding processes to the extensive joining of heavy plates.

### Riveting Requirements and General Methods of Driving Rivets

The requirements necessary to produce good tight rivets are as follows: The holes must be practically in line; the plates must be well bolted together; the rivet heads must be up against the plate; the rivet necks must fill the hole; the rivets must be hot enough to expand and fill the hole the entire length when driven; the holding-on device must hold the rivet firmly in place; the riveting machine must have sufficient power to form the rivet before it gets too cold to fill the hole. A rivet which is loose in the hole may be calked up so that it will pass the inspectors' testing hammer, but such a rivet will not hold its estimated load under a breaking strain, and any large percentage of such rivets would lower the efficiency of the joint to the danger point.

Referring especially to ship-work, there are two different ways of driving rivets: one is the one-man machine method, and the other is the two-man "hand-gang" method using hand-hammers. Driving rivets by hand is a business that requires some natural aptitude and training, extending over considerable time and demanding much experience. A hand-gang is, therefore, likely to have had more experience and be more skilled in the business than the machine man. This is partly the reason why hand-driven rivets have in the past had a better reputation than machine-driven rivets. Given a husky machine man who knows the business, in combination with a good machine, proper air-pressure, a heater who will "get 'em hot," and a holder-on who will "get the

[1]Address: 4237 Viola St., Philadelphia, Pa.

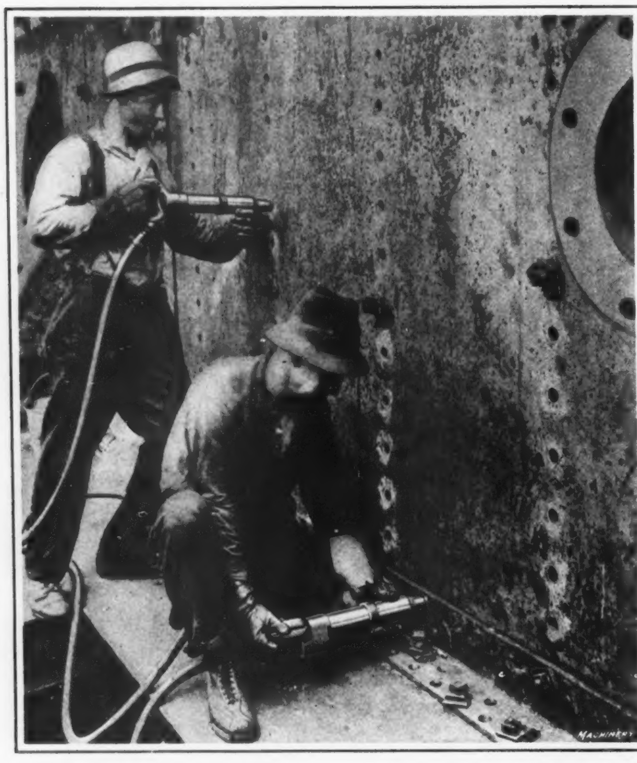


Fig. 1. Long-stroke Riveting Hammers made by Independent Pneumatic Tool Co. driving 7/8-inch "Flush" Rivets in Engine-room Bulkheads

heads up," and the machine man will do more work than the hand-gang and it will be equally good. There are many places where it is not convenient to pipe the air to the job, or to rig up for a few rivets. In these places hand work is more economical.

In our present emergency, hand work is out of the question, for the supply of skilled workers is very limited; therefore, broadly speaking, all of our new ships are likely to be machine riveted. The "long-stroke" air hammer is the type adapted to the general run of riveting. Driving rivets with one of these hammers is a strenuous occupation and calls for a strong man hardened by experience. The hammer weighs about 25 pounds and contains a solid steel plunger 1 1/16 inch by 2 1/2 inches, which makes 600 or 800 strokes per minute. The length of the stroke varies for different hammers, and may be 6, 8, 9 or 11 inches. The vibration added to the weight increases the difficulty of holding and controlling the machine. In driving cone-head or button-head rivets, the head of the rivet helps to hold the machine in place while the rivet is being headed. In the "flush riveting" such as is required on the outside shell of a ship, the machine must be guided and controlled without this assistance from the rivet head, which is flattened until it is either flush with the surface of the plate or slightly convex.

Appliances of various kinds have been made to hold the machine in position and to relieve the operator of the weight and vibration. Generally speaking, they are not much used, as the men will not take the trouble to rig them up. Under present conditions, where many inexperienced men must be taught to drive shell rivets (the rivets in the outer shell which require a flush head), it is probable that interest in these devices will be revived and improvements made.

Wherever cone-head or button-head rivets are to be driven and a convenient backing is available, the so-called "jam-hammers" may be used to advantage. These consist of a riveting hammer telescoping in an air cylinder in such a way that the hammer is thrust out against the rivet, the backing taking all the weight and vibration. Many records for fast work have been established with these machines. The work is likely to be uniformly good, as they strike a harder blow than the pneumatic hammers which are held by hand. These machines may be opposed by the regular holding-on machines, or one jam-hammer may be used to work against another. If this is done, an extra-heavy die should be used in the holding-on machine. The foreman should keep in mind that wherever the weight and vibration of the machine can be taken by some mechanical device, the operator is relieved of the hardest part of the work, and, other things being equal, more work should be done.

Under the system being adopted for the construction of our new ships, certain assembled units are being fabricated in inland shops and assembled in the shipyards. This makes it possible for some of the riveting to be done by the shop machines, the use of which has heretofore been confined principally to boiler and structural work.

### Pressure Riveting Machines

Where a sufficiently strong backing may be obtained behind the rivet, the best possible kind of work may be secured by steady pressure. Generally speaking, there are two kinds of machines used for this purpose; one comprises a yoke and a single cylinder and piston operated by direct hydraulic pressure, and the other is a pneumatic machine, consisting of a yoke and a cylinder containing a piston operated by air pressure. The pressure necessary for riveting is obtained by a system of toggles or levers.

To form a good rivet of the ordinary sizes (3/4 to 1 inch), about 60 tons pressure is required, but the full pressure of the machine, which may amount to 100 tons or more, is usually applied to all the larger sizes indiscriminately. The yoke which carries the holding-on die must be sufficiently strong to withstand this pressure. If the depth of the yoke is sufficient to take in wide plates, the weight becomes so great that the machine is made stationary and the work is carried to the machine. Up to a 20-inch or 30-inch gap, it is within limits to carry the machine to the work.

Very fast and satisfactory work can be done with these machines, but their use is limited to such work as can be spanned by the yoke, or such work as can be economically lifted and moved to position by the crane. A light yoke riveter of comparatively deep gap may be equipped with a heavy "jam-hammer" on one end and a holding die on the other, and drive the rivet by a great number of rapid blows rather than a single application of heavy pressure. This type has the advantage of lightness as compared with the pressure riveters, but is not quite as rapid and does not insure that the work will be pressed solidly together as does the pressure system. The ultimate strength of a joint riveted by heavy pressure is no greater than that of one riveted by hand or by an air hammer, but the pressure-riveted joint will stand a much greater strain before visible "slip" or yield occurs. Some of the pressure riveters are also arranged to be used for punching holes in plates. The rivet-forming dies are simply replaced with a punch and die.

For doing speedy work with these machines, it must be remembered that the time actually required to drive the rivets is small, and that the delays occur in getting the rivets in the holes or shifting the machine; therefore, care should be taken to have every convenience provided to facilitate these operations.

### Importance of Care in Laying Out Rivet Holes

Each shop has its own system of laying out the holes. While the general method is about the same, some concerns have adopted and developed refinements not used by the others. As a result, the work turned out by some shops can be erected with the minimum amount of trouble, while others have a good deal of unnecessary reaming and pinning to do to bring the holes of adjacent parts into alignment. A little careless work in laying out or punching the holes or in making the templets is paid for ten times over in erecting. Under the system of ship construction now being adopted, of fabricating small units in various widely scattered shops, endless trouble would be experienced by the erecting yards if the greatest care were not observed in laying out the holes.

### Suitable Rivets

It should be the duty of the foreman to see that rivets of the right length for the plates, laps, and frames are available and convenient for the heaters, so that no time will be lost in hunting them after the work is started. "Swell-necked" rivets are sometimes used where trouble is experienced in fill-

ing the holes on the head side. When these are used, care must be taken to get the heads up against the plate before riveting. Usually they are driven home with a heavy hammer before "holding-on."

### Heating Rivets

Various methods of heating the rivets are employed, depending on the conditions. The foreman should make it a point to be certain that the rivets are being heated as fast as they can be used; if they are not, he should revise his method of heating. The common hand-forge serves the purpose where the speed of the work is limited for some reason, or if there are frequent delays. A "fire-pot" using hard coal or coke and furnished with an air blast from the compressed air hose is quite a satisfactory device for heating rivets rapidly, but the rivets may be burned if there are frequent delays and care is not used in regulating the fire. The gas or oil furnace is adapted to conditions where a great many rivets are used. The heating furnace should be set up where it will be convenient to the job. If ventilation or other conditions make this impossible, convenient arrangements to pass the rivets should be provided. Oftentimes a length of 2-inch pipe makes a good tube through which the rivets may be dropped by the heater and guided to the holder-on, lower down in the ship. A foreman who is interested in the work will see that such conveniences are supplied.

### Bolting Up Plates before Riveting

The work should not be turned over to the riveters until it has passed a careful inspection to insure that it is properly bolted up. The plates must be in absolute contact; otherwise the rivets will not be tight. The bolts should be so arranged that the riveter can remove them with the minimum amount of trouble and delay. The time of a bolting-up gang is worth less per hour than that of a riveting gang, and it is, therefore, economy to have them do as large a share of this work as possible. If the bolts are too long, or put in without washers, the riveter is delayed while he unscrews the nut a dozen unnecessary turns.

If the yard economizes by using old bolts with bad threads, the riveter may have to use a wrench to unscrew the nut the entire length of the bolt. Where the thread is right, the nut, once loosened, can easily be taken off with the fingers. Sometimes, in drawing up the work, the plates shift and bind the bolts in the holes. In such cases, the bolting-up gang should remove the bolt and shift it to an adjacent hole, either reaming or pinning the bad hole until a rivet will enter. Otherwise the job will have to be done by the riveter.

Where soft packing is used between plates, the greatest care must be taken to have the work tightly bolted together. Extra bolts should be used and they should all be gone over several times, drawing down one after another until all the yield is taken out of the packing. Otherwise the heat and drawing effect of the rivets will loosen the whole joint. The bolting-up gang should make free use of the heavy sledge hammer and test the joints with a thin blade to make sure there is no open space between the plates. When the bolting-up is properly done, the riveter should be able to take out the bolts without delay and get the rivets through the holes without trouble. Also the driving of one rivet should not loosen any of the rivets previously driven. All liners and fillers should be in place before the riveting is started. Going back to drive a half dozen rivets in a liner which was not ready means an extra shipping of both the riveting and holding-on equipment, and will probably cost as much as 100 rivets driven in the ordinary way.

### Advantages of Reaming Holes before Riveting

When holes are punched in heavy steel plates, the metal surrounding the hole is stressed and cracked until its condition somewhat resembles a bullet hole in a pane of glass. Under heavy strain, these minute cracks will widen and the plate will break. The loss of strength from using punched holes without reaming is estimated at 26 per cent for 1/2-inch plate and 33 per cent for 3/4-inch plate. The full strength of the plate is restored if the hole is reamed to remove the stressed material. About 1/8 inch on the diameter is allowed for reaming 7/8-inch holes. While the increase in strength due to reaming is generally known, in many places—especially on repair work—it is not given consideration and the holes are punched to full clearance size.

In all plate work there is bound to be a certain percentage of holes which will show faulty alignment. If the holes are very bad, they should be reamed to the next size larger and a larger rivet used, as otherwise the conditions shown at *A* in Fig. 5 will obtain. If care is taken to use extra long rivets and to have them well heated the entire length, such holes can be filled up, but often empty pockets are left, as indicated by the illustration, and the joint loses in strength.

The reaming of holes is such an extensive operation, and at best requires so much time and expense, that it deserves especial consideration. In shipyard work, a large percentage of this reaming is done after the work is assembled, and, therefore, it is usually most convenient to do it by means of the pneumatic machines.

### Machines for Reaming Rivet Holes and their Use

The machines used for reaming rivet holes are made in a wide range of sizes from the small high-speed machines weighing about 8 pounds to the large slow-geared machines weighing up to 100 pounds. The machines used for the average all-around drilling and reaming weigh about 30 pounds, and develop about 3/4 horsepower under ordinary working conditions. They are used for drilling, reaming, flue rolling and cutting, and for driving various small portable machines, such as port-light cutters, boring-bars, etc. Fig. 2 illustrates how rivet holes are reamed, the machine being handled by two men.

The electric machines compete with them to some extent, but the great advantage of the air machine lies in its light weight as compared with the power developed. For the light work—say drilling up to half-inch holes—the extra weight of the electric machine is not of much consequence, but even for this class of work an air machine may be selected as heavy as can be handled conveniently, and its surplus power used to give a higher drilling speed.

The mechanic trained in the tool-room of a high-class plant, who has learned that a reamer is an article to be treated with respect, that its edge must be guarded carefully against injury and its lubrication given constant attention, requires some little time to readjust his views to the accepted practice of the ship-workers reaming rough holes with an air machine. He is right in believing that they abuse the machine; they also abuse the reamer, they fail to lubricate it properly, and they seldom have the reamer properly sharpened. These facts

Fig. 2. Reaming Holes in Shell Plates of Ship, using Machine made by Ingersoll-Rand Co.

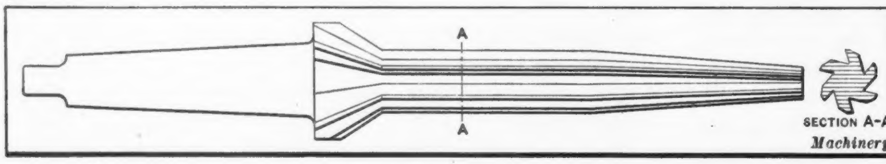



Fig. 3. Combined Reamer and Countersink used to insure that Conical and Straight Sections of Rivet Hole are Concentric

he notes at once, but after a time he also learns that it is not possible to get a full crew of men who will take care of the tools; that the extra work obtained from the rough-and-ready method of jabbing the tool in the hole as fast as possible, and proceeding to the next more than pays for the tools destroyed; that dwelling too much on the injurious effects of scanty lubrication and burned reamers makes the men overcareful and slows down the work; that if the tool is kept hard at work, it will, in the course of a day, earn enough money to buy several new reamers. The skill of the tool-room man should be employed to put the reamer in the best possible cutting condition. If this is done, it will cut itself clear and not be nearly so liable to injury, besides doing more work. The efficiency of the operator may vary several hundred per cent under different management. It is a common sight in a shipyard to see two men struggling with a machine, reaming, say, 7/8-inch holes. They are certainly working hard, and, on the face of it, there seems nothing to criticize. A closer observation may show that the machine lacks power to turn the reamer in the hole; that the reamer often sticks in the hole and pulls out of the machine; that the reamer is dull and worn out or badly sharpened, or blunt on the point; and that, while the men are working hard, they are not accomplishing results comparable with their efforts.

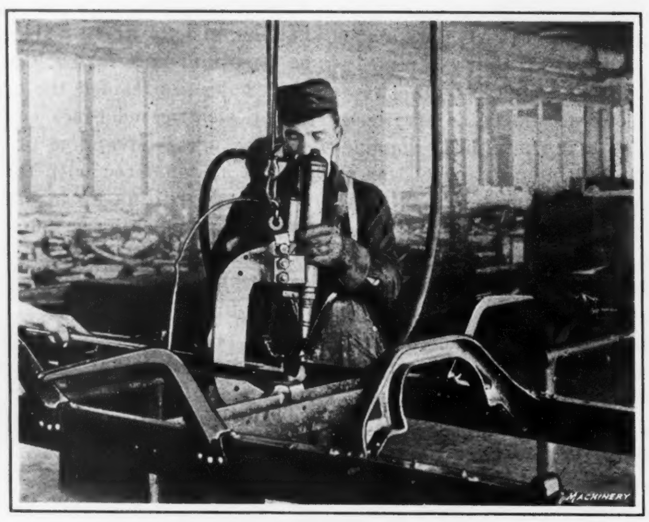


Fig. 4. Riveting Automobile Frame with Yoke Riveter made by Chicago Pneumatic Tool Co.

One of the New England yards maintaining this "economical" type of equipment decided to reform. Each gang was given two new reamers and a pot of tallow for lubricating the reamer, and only machines which passed a standard power test were sent out. The men were given an incentive to do as much work as possible. They had been doing an average of twelve holes per hour counting delays. The average output immediately jumped to fifty holes per hour and there were no delays. In this case a little intelligent supervision plus a small increase in cost of equipment increased the output 40 per cent on the same "overhead."

The following combination of troubles is very commonly met with. A department superintendent saves money by skimping on drills, reamers, or countersinks. A cheap or overworked repair man has neither time, equipment nor ability to maintain the machines to full power and efficiency. An overtaxed air compressor is unable to deliver full pressure to the mains. Undersized mains are unable to convey a full supply to distant parts of the yard, and perhaps, as a final touch, a machine which requires a full 1/2-inch pipe is taking air through a 1/4-inch nipple, or 3/8-inch hose "leader." Ice in the hose may further reduce the power or cut it off completely. In a plant of any size, these conditions can only be prevented by having one man give his entire time to supervising the general conditions of the air plant and equipment and operation, and be responsible for them directly to the main office, independent of foremen and superintendents. Experience has shown that yard foremen and even officials higher up are blind to these conditions and are slow to move in the direction of reform. Also, each department is likely to advance its own ends at the expense of other departments where this can be done.

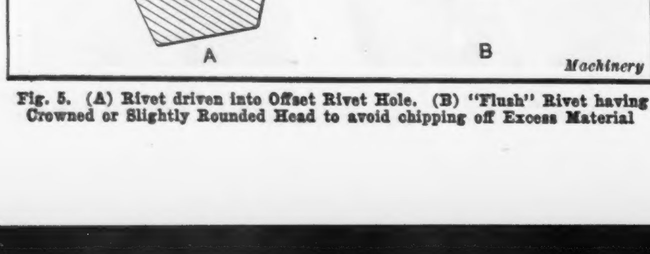



Fig. 5. (A) Rivet driven into Offset Rivet Hole. (B) "Flush" Rivet having Crowned or Slightly Rounded Head to avoid chipping off Excess Material

### Countersinking Rivet Holes

When countersinking rivet holes for flush work, etc., care should be taken to insure that the countersink is concentric with the hole. Some yards use a combined reamer and countersink of the form shown in Fig. 3, which insures a concentric countersink under all conditions. It is very common to see the holes countersunk all on one side, especially where the holes are crooked or near an angle. Of course, a rivet cannot be expected to show 100 per cent holding power under these conditions. Where conditions demand that the rivets must be finished absolutely flat with the plate, as in deck work, the only way of insuring this is to use rivets a trifle too long, and chip off the surplus material while hot. Oftentimes where "flush" rivets are specified, it is not important that they be finished absolutely flat, and the work of chipping may be avoided by using a die having a very flat cup and finishing the heads with a slight crown, as shown at *B* in Fig. 5. This does away with chipping and at the same time insures a full head.

The equipment for countersinking must include sharp countersinks; otherwise much time will be lost in forcing them to cut. It is important that the shanks of both reamers and countersinks should fit well in the socket, as there is no constant pressure to hold them in place, as in drilling. If they keep pulling out, the workman will probably "rough" the shank with a chisel and drive it in. If he avoids splitting the socket driving it in, he is likely to do some damage in getting it out.

Under present conditions, where the work is standardized and units are fabricated in the shops, it should be possible to do a considerable portion of the reaming by the shop machines operated by one man. Under the best conditions, there will remain millions of holes to be reamed in the yard.

### Hammer Signals of Riveting Gang

The riveter generally arranges a code of signals with his holder-on whereby he may communicate his next move through the side of the ship or bulkhead which usually separates them. For instance, continued blows of the hammer means "Hurry up—come on with the rivets." Two short blows means "Go back and hold on the last rivet driven to finish up the head." Three short blows means "Take out the rivet"; if followed by continuous blows, the signal means "Come on with the rivets and get them hot." The most common reason for taking out a rivet without driving it is because it is not hot enough. A riveter and holder-on who are accustomed to working together soon learn each other habits or

methods and are able to cooperate without frequent delays for conference.

Because of the noise and difficulty of talking through the side of the ship, these hammer signals should be sufficiently well understood to enable the riveter to signal all his more common wants. Such items as "rivets too long," "too short," "not hot enough," "get on the last rivet," "wait awhile," "come on with the rivets," "in the wrong hole," etc., should be well understood. Because of this understanding that is established between the members of the riveting gang, it is customary for a foreman to keep the gang intact, and always assign the same men to work together where possible.

### Driving Rivets

The importance of having the machine used for rivet driving in first-class order is not usually given the consideration which it deserves. When, for instance, a riveting hammer gets out of order, it means that one man makes a trip to the tool-shop with the machine while the other two or three men comprising the gang are glad of the excuse to await his return, doing nothing in the meantime. When he returns, very likely the gang is scattered and the fire low, often making a total delay of an hour or more for the three or four men. Then if the machine sticks or "kicks" or lacks power, the riveter may put up with it rather than risk a "call-down" for further delay, and, as a result, work is done which will later require to be calked or cut out.

In the actual driving of rivets, the result depends largely upon the skill of the man operating the machine. If all the preliminaries referred to have been properly taken care of, almost any man of reasonable intelligence can quickly learn to drive rivets. More than average strength and endurance are required, however, but not more than may be found in thousands of men adapted to this work.

In driving cone-head or button-head rivets, they should be "plugged" squarely into the hole, care being taken not to bend over the point of the rivet, but to upset it, filling the hole its entire length. The machine should be strong enough to form a perfect head without rocking to work down the edges. The machine should be started off lightly until the rivet has settled into the hole somewhat, to prevent bending to one side. In driving any kind of rivets held or backed up by a dolly-bar or hand-hammer, the riveter must learn to run his machine slowly until enough head is formed to hold the rivet in the hole, as otherwise the holder-on will have difficulty in keeping the hammer or dolly-bar on the rivet.

The necessary equipment for driving flush rivets includes a pneumatic clipping hammer and several "hot-flat" chisels for chipping off the surplus material. The extra difficulty of driving flush rivets lies in the necessity of getting the rivet headed to a point where the surplus metal may be chipped off while it is still hot and soft, and the difficulty of holding and guiding a flat die on a flat surface. The rivet must be plugged in the hole and the surplus metal worked over to one side and chipped off as quickly as possible. The rivet may then be finished down to a flat surface or, on shell work, left slightly rounding.

In driving flush rivets, it is customary to go back to the last one driven and give it an extra finishing after it has cooled somewhat. A blow must never be struck on a rivet point until the holder-on has his hammer or dolly-bar firmly on the head, because the rivet is likely to be loosened. When there is a large amount of deck work to be riveted, it pays to rig up a "deck machine," which is a riveter carried by some kind of support. A common rig is a kind of wheelbarrow which holds the riveting machine in a vertical position and has two handles whereby it may be wheeled about and guided on the rivet. Sometimes it pays to provide an extra man to chip the rivet when using this type of machine.

### Holding-on

Getting the rivets into the holes hot and "getting the heads up" is a necessary preliminary to obtaining tight work, and it is up to the holder-on to see that this is done. The device used to hold the rivet in position while it is being driven should be adapted to the work. In any case, mere pressure will not suffice. There must be sufficient weight behind the rivet to form a solid anvil against which it may be headed. For general use in connection with air hammers, the pneumatic "holder-on" is best adapted. These are made by several companies, but are all of practically similar construction. A solid piston of steel of about 3 inches in diameter works in a cylinder and is forced out by air pressure. One end carries a die adapted to fit the head of the rivet. The other end of the machine is extended by screwing in a piece of pipe of convenient length to reach some solid backing.

Fig. 6. Holding-on with Offset Dolly-bar


Fig. 7. Dolly-bar used as Lever for holding-on

A foreman or tool-man may save considerable time by arranging convenient backing for these machines. Often a long plank is rigged up with bolts at each end extending through rivet holes in the ship, or hooks may be attached to the machine to hook over channels or I-beams. When working under decks from a staging, the extension of the machine usually rests on the staging. As the thrust of the air cylinder may easily amount to 500 or 600 pounds, care must be taken to have the staging strong enough to withstand this extra strain. The pneumatic "holder-on" is usually tapped out to receive ¾-inch pipe for the extension. Up to a length of about 3 feet, ¾-inch pipe is sufficiently strong for the purpose, but when, as sometimes happens, it is necessary to have this extension tail 5 or 6 feet long, larger pipe should be used to avoid dangerous accidents. It is a good plan to use a short piece of solid iron rod threaded into a 1¼- by ¾-inch malleable iron pipe coupling and use 1¼-inch pipe for the longer extensions. If the connection is a ¾-inch pipe-nipple, it is likely to break.

The piston of the holding machine should be in good order and work freely in the cylinder, so that it will fall back of its own weight. The valve should be tight, as otherwise the plunger will push out and bother the holder-on while he is trying to adjust the rivet. If the holes are reasonably good, these machines will hold the rivet heads up against the plate satisfactorily, but when the hole is tight or crooked, the head should be driven up with a heavy hammer before applying the "holder-on" to it. A husky man can hold-on rivets for the air hammers with a dolly-bar or hand holding-on hammer and do good work, but it is much harder than using the pneumatic holding machine. (See Figs. 6 to 9, inclusive). Where there are only a few holes in a compartment, or convenient backing is not available, it does not pay to run an air hose and rig up a pneumatic holding machine.

Under normal conditions, these machines will save much time and labor, and they require less skill and experience than the hand method. When the rivets are to be driven by hand, the hand-holding hammer or dolly-bar is the most satisfactory, as it rebounds under the impact of the heavy blow of the hand-hammer and "gets the head up." The pneumatic holding machine is likely to yield somewhat to the heavy blow and fail to come back strong enough to get the head up in every instance when used in connection with hand work. Crooked-neck dies may be used in the holding machines to extend around angles, but they must be rigid, because any elasticity in the neck will result in a yielding action and the rivet will not be held solidly enough to insure good work.

Where the rivets fit easily in the holes, and the holes are clean-cut and sound on the head side, perfectly good work is obtained by the use of the simple pneumatic holding-on machine. Under conditions which sometimes obtain in repair work, especially where old rivets have been cut out and the holes reamed again, many of the holes will be bad on the head side, and the rivet head cannot be put against the plate or held there by pressure alone. Under these conditions, the holding-on machines will not do satisfactory work if used alone. The rivets may be driven up with a heavy hammer before putting the machine on, or one of the hammer-holding machines may be used. These machines consist of a plain holding-on machine having the thrust cylinder, and also a light pneumatic riveting hammer inside of the cylinder which may be operated to drive up the head of the rivet and then be shut off without releasing the thrust.

Fig. 8. Dolly-bar having Extension to serve as Fulcrum

When the rivet heads need hammering, some yards permit the use of a regular pneumatic riveting hammer as a dolly-bar to hold-on the rivet. The air is turned on long enough to drive the head up, after which the machine is used dead and acts the same as any solid dolly-bar. In theory, this is not good for the hammer, although in practice it is not often that any damage results, except the damage to the dies caused by the extra heating.

Fig. 10 illustrates the use of the self-supporting pneumatic hammer (made by the Independent Pneumatic Tool Co.) for holding on while driving 7/8-inch rivets with a riveting hammer. These self-supporting hammers are usually used in pairs. When applied in this way, the cut-off valve admitting air to the cylinder of the "holder-on" end is opened on both machines. The throttle valves of the riveting hammer ends are then opened and both machines are started at the same time.

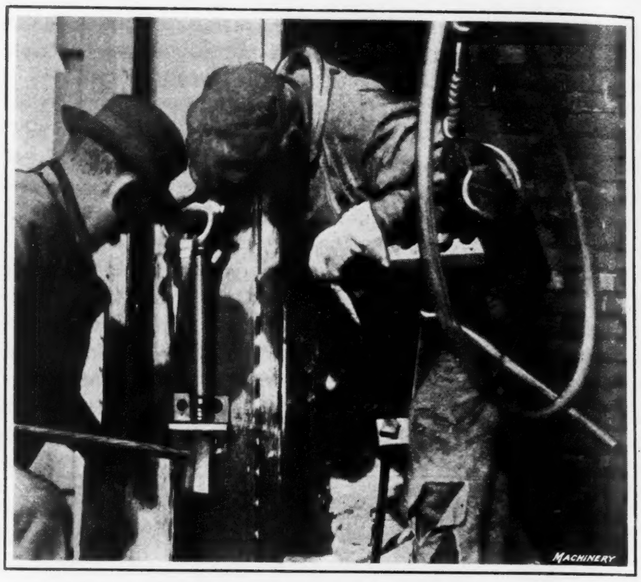


Fig. 9. One Method of using Hand Holding-on Hammer

They also should be stopped simultaneously after completing the riveting operation.

### Cutting Out Defective Rivets

Oftentimes it is necessary to cut out one or more bad rivets. Formerly it was the custom to do this work with a pneumatic chipping hammer. A slot was cut through the head, making it like a slotted screw-head, after which the backing-out punch and sledge hammer would do the rest. It is a convenience to have backing-out punches made to fit the pneumatic riveting hammer, which enables the riveter to back out the rivets without the assistance of a helper to swing the sledge. Many shipyards now burn off the heads of defective rivets with the oxy-acetylene flame. The burning torches are connected by long sections of hose, and it only requires about a half minute to burn off a rivet head. Either countersunk or button-head rivets can be melted or burned off clean without damaging the plate. The chipping process requires a much longer time. Sometimes when the burning equipment is at hand, the riveter will use it to reheat a bad rivet and will thus be enabled to finish it off without cutting it out. Or if a single rivet is too long, he will use the torch to burn the end off, thus making it the right length.

Where a lot of old work is to be cut out, a gang of burners is assembled to burn off the heads in wholesale fashion. Sometimes in oil-ship work this cannot be done on account of the fire risk. In such cases, flush rivets are usually drilled and punched out, and where possible the pneumatic "rivet busters" are used on the button-head rivets. If properly rigged up, these "busters" will knock off heads about four or five times faster than they can be burned, four or five 7/8-inch rivets to a minute not being uncommon.

### Selection of Equipment

While a part of the shop work on our new ship parts will undoubtedly come within the range of the pressure riveters, the assembler's work in the yards will have to be riveted by the air hammers as usual. The selection, operation, maintenance, repair, and equipment of these air hammers is a subject which demands the careful consideration of all construction superintendents having this department in hand.

The hammer selected should be powerful in its action, operate with a minimum of vibration, be well balanced in its design, and convenient to hold and guide. The efficient operation of these riveting hammers or "machines" should be facili-

tated by insuring a good supply of air and convenient hose connections, means for keeping the line free from ice, and provision for oiling the machines as required. The tool-room should be supplied with spare parts and be able to supply promptly such accessories and conveniences as experience has shown will promote the work. As nearly all disorders to which these machines are subject operate either to reduce the power of the machine or to increase the vibration, the repair man should be competent to remedy such disorders with the minimum delay. Efficient and economical service demands that the riveting hammer shall deliver sufficient power to drive the rivet while it is still hot; that it shall not "kick" or vibrate to an extent which makes it difficult to hold or guide; and that it shall respond to the throttle promptly, giving light or heavy blows, as desired, under the full control of the operator.

For supplying air to the average riveting hammer, 50 feet of 3/4-inch hose, with 10 feet of 1/2-inch "leader" hose attached is the usual equipment. No connection should be smaller than a 1/2-inch pipe-nipple, if the full power of the hammer is required. When the air pressure is low, an increase in power may often be obtained by discarding the "leader" and connecting the 3/4-inch hose directly to the hammer. Of course, it is less convenient to manipulate a hammer connected to a large hose, but this inconvenience may be endured better than the lack of power.

The shop should furnish "clips" or springs which have not been bent out of shape. The "clip" should be capable of holding the riveting die or "set" in place when the hammer is quickly picked up by the handle. Otherwise the "economy" in 25-cent clips is likely to result in the loss of a $1.25 set and a $1.50 plunger.

Many riveters place leather cuffs around the neck of the set for convenience in holding the hot set when the work is coming fast, but this is generally regarded as an individual convenience, and is done by the riveter to suit himself. The shop may save time by contributing a piece of old belting, a belt lacing, and some tacks, or keeping these materials on hand for this purpose. The set or die should be adapted to the work, and be kept sharp and clean. The recent advance in the price of tool steel has resulted in the use of a cheap steel for dies, the surface being hardened by the pack-hardening process. When these dies become soft and a burr is formed on the edges, they may be annealed and reshaped with an old countersink, and rehardened by heating them nearly to the burning point and, after treating the ends with cyanide, plunging them into cold salt water; some of them will crack, but not a large percentage. If the dies are badly out of shape, they may be turned up in a lathe before hardening.

Recent improvements in riveting hammers has made the 6-inch size so strong and fast that it is quite generally used for the average run of work, only a few of the heavy machines being carried for special work. While this practice is not universal, it is becoming quite general. Considering the hammer itself, the 6-inch machine may weigh about 25 pounds. Practically all the hammers have a 1 1/16-inch bore. The size, whether 6-, 8-, 9-inch, etc., indicates the stroke of the plunger, which is a piece of hardened steel carefully ground to fit the cylinder. The plungers vary in length from 2 1/8 to 4 inches. The length of the plunger has an important effect on the operation of the machine.

For many years the manufacturers of riveting machines have consistently opposed the use of short plungers. In spite of the opposition, the workmen have persisted in reducing the standard length of plunger, and the idea was gradually forced on the manufacturers until they now realize that advantages are gained from the use of a plunger shorter than their original standard. Machines which were formerly equipped with 3-inch plungers are now operated with 2½-inch plungers. Machines with shorter plungers run faster, with less vibration, apparently do as much work and are easier to control. What is lost in weight of plunger is gained by length of travel. The companies opposed this practice largely because the workmen in cutting down the plungers left the ends rough or soft, so that they would either chip off pieces or expand and stick in the machine. The modern riveting machines are perfectly adapted to the use of the 2½-inch plunger and it has now become standard equipment.

### Riveting Hammer Troubles and Repairs

The cylinder of a pneumatic hammer is open at one end to receive the shank of the die which forms the head of the rivet. The plunger in the cylinder makes from 600 to 800 strokes per minute, striking the shank of the die at one end and an air cushion at the other end. It is apparent that the admission and exhaust of air must be correct or there will be trouble. There are two principal causes of defective operation, lack of power and excessive vibration. The valve which controls admission of air to the cylinder is operated by the air pressure acting on its various shoulders, the admission of air being controlled by the plunger. When the plunger is at the limit of its stroke, it uncovers a drilled port which admits air to reverse the valve. If this port is plugged up or the valve leaks around the shoulder, or some of the air escapes through leaky joints, or the valve sticks, the plunger will not reverse quickly and the machine will either develop excessive vibration or lack power, or both; probably it will also run slowly. Owing to this intangible connection between the piston and the valve, these machines require especial study on the part of the repair man. The design and location of the valves in different styles of machines varies, but all depend on air pressure working through drilled ports to operate the valve.

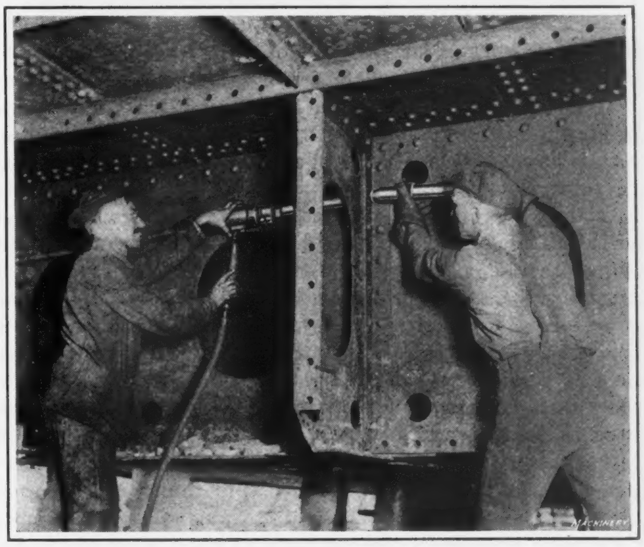


Fig. 10. Self-supporting Hammer holding-on while driving 7/8-inch Rivets

Only a small percentage of the repair men ever learn exactly why or how these machines operate, but if they will remember that they worked properly when they left the factory and learn to keep them in their original condition, it is all that is necessary. Even this is not so simple as it sounds, but it may be accomplished by a little care and observation. When a repair man inherits machines which have been handled by some predecessor, he may safely assume that some damage has been done to the inside by careless handling. As the machines come in for cleaning or repairs, he should examine carefully the surfaces which are supposed to fit together with an air-tight joint, and remove any burrs with a very fine flat file, countersinking the dowel-pin holes slightly to provide clearance for the ring which usually surrounds the dowel-pin on the corresponding part.

The repair man should frequently try out on a heavy block of wood, arranged for this purpose, one of the riveting hammers which is known to have sufficient power and to run smoothly. With the operating characteristics of this machine as a standard, he will soon learn how fast a machine ought to run, how much vibration is to be expected under normal conditions, and how rapidly the die ought to cut into the wooden block when the machine is developing normal power. With these standards in mind, he can test doubtful machines and know by the comparison whether or not they are right. All of the hammers should be numbered and a record should be kept of each time they come in for repairs. For instance, if

No. 6 comes in a dozen times during the week for lack of power or excessive "kick," he will know that there is something radically wrong and go after it.

Often the men complain without cause, or the fault may be in low air pressure or plugged hose. The repair man should know his machines well enough to be able to state positively whether the machine is right or not. When the machine has plenty of power, but is slow or "kicks," or refuses to start off promptly, it generally means that either the plunger is sticking in the cylinder or that the valve is sticking at one end of its stroke. The plunger should fall freely the entire length of the cylinder by its own weight. If it fails to do this, examine it carefully and it will most likely be found to have particles of hard material sticking to the polished surface. These should be removed with an oil-stone or by other means which will not scratch the surface. Generally by forcing the hard plunger through the well-oiled cylinder several times, any rough spots in the cylinder will be smoothed down. If not, the cylinder may be made smooth by using crocus cloth on a wooden mandrel.

After the plunger is known to be running smoothly, the valve should be examined to see if it travels freely. Before taking the valve apart, move it with the fingers the entire length of its travel, being sure that it is making full-stroke. It should not have the slightest tendency to stick at the end of the stroke, and if it is of a type which has tension springs, it should not move so freely as to fall of its own weight in either direction. If the valve sticks, find the rough spot and carefully smooth it either with a half-round very fine file, crocus cloth or scraper, being careful not to cut away any of the metal except the edges of the scratch. Oftentimes washing it with kerosene is sufficient. If the hammer refuses to start promptly, but has no other trouble, it is likely that the valve is too tight. Its action should be compared with the standard previously referred to. When springs or other means are provided to adjust the tension of the valve, these springs should be examined carefully for sharp corners, or any projecting ends which may be responsible for the irregular action. If the valve starts too easily, it will open and close the ports and reverse the air admission before the piston has had time to follow its action. It is assumed that the repair man will always clean out all of the drilled parts and pin-holes, being careful not to overlook any of the smaller ones. If the valves or any removable parts of the machine are aligned or positioned by dowel-pins, care should be exercised to see that the dowel-pins are in the right holes before force is applied. Frequently the surfaces of such parts are badly defaced from careless work of this kind. A mysterious loss of power may sometimes be traced to the leakage occurring between such defaced surfaces. When such damage is sufficiently serious to affect the operation of the machine, refacing in a lathe is generally required before the defect can be overcome. If adjustable or renewable tension springs are provided to overcome the loose action resulting from wear to the valve, and if the repair-man does not unnecessarily cut away the important surfaces of the valve in connection with cleaning or smoothing operations, it will be a long time before the valve will require complete renewal. If the tension spring is kept at the proper tension, and all the joints are kept smooth and air-tight, as may easily be done, the hammer will give several years of hard service without requiring extensive renewals for wear.

When the hammer makes a loud purring noise, but refuses to start, it indicates that the valve is only traveling part stroke, not going far enough to admit air under the piston, or reversing before the piston has time to move. It may also indicate excessive leakage around the shank of the die. This condition can generally be overcome by making the valve tighter and making sure that all joints are tight. It often indicates a broken tension spring. In the type of valve which has no tension spring, it may indicate that the valve is worn. In the hammers which have no springs or means of adjustment, the troubles may generally be traced to scratches, particles of sand, scale or rust, or excessive wear.

One of the indispensable requirements of the repair shop is a tank of kerosene or gasoline for washing out the hammers. The tank should be large enough to submerge several hammers at the same time. A galvanized iron box about 12 by 24 inches and 12 inches deep, with a cover, is about what is required. Many times, simply soaking in this tank for ten minutes will cure the trouble and prevent the necessity of taking the hammer apart. Gasoline is the most satisfactory for cleaning purposes, but its use is sometimes prohibited by the fire risk.

* * *

## AIR-TIGHT CASTINGS

The greatest care must be exercised from the designing of a piece to the pouring of the metal, in order to obtain a solid, air-tight casting, and even then failures are likely to occur. Brass and bronze are the metals best adapted for use in the manufacture of air-tight castings. Strength may be produced by proper design, but the desirable quality of density is not easily obtained, due no doubt, to the many variable and uncertain elements which enter into the process of manufacture.

The design of the casting has an important bearing upon the ultimate success of the casting. The designer should guard against draws by having all cross-sections of approximately equal thickness, or by providing access to all large sections to allow the use of chills. When large cores are used, they will act as chills. The use of large fillets should be avoided, so that excessive masses of metal will not be concentrated at one point. The patternmaker must know what chills are to be used so that large chilled surfaces may be placed in a vertical position and thus prevent the metal from "kicking off" these surfaces. An exceptionally clean casting may be obtained by gating it to another casting in which all the dirt will be accumulated. A clean mold is absolutely essential in air-tight castings. It is necessary that the unimportant parts be placed high in the cope, so that the loose sand in the mold may flow to them. In general, chills should be used on all enlarged sections which are in close proximity to smaller ones and connected to them. Use a sinking-head placed at the heavy part of the castings of exceptionally large sections. Gate the castings at a light section, using a heavy upright pouring gate as near the pattern as possible. To safeguard against draws in the casting at the gate, the gate leading from the pouring gate to the pattern should be large at the pouring gate and reduced sharply into the pattern.

The following alloys have been tried and found satisfactory for making air-tight castings:

COMPOSITION OF METAL FOR AIR-TIGHT CASTINGS

| Alloy No. | Copper, Per Cent | Tin, Per Cent | Zinc, Per Cent | Lead, Per Cent |
|---|---|---|---|---|
| 1 | 72.50 | 1.75 | 19.25 | 6.50 |
| 2 | 82.00 | 7.50 | 4.75 | 5.75 |
| 3 | 83.00 | 11.50 | 4.00 | 1.50 |

*Machinery*

Alloy No. 1 is used for ordinary castings and is easily machined, while alloys Nos. 2 and 3 are used on high pressures and are proportionally harder to machine. The treatment of the metal in the furnace is of vital importance. Proper allowance for oxidation of zinc must be made, otherwise a satisfactory alloy will not be produced. If the metal is not taken from the furnace when it reaches the proper heat, but is allowed to soak in the furnace, it will assimilate gases and the castings may be porous. Many castings are no doubt spoiled, because of carelessness in pouring. If the temperature is too cold it is almost impossible to obtain solid castings; if poured too hot, the castings may be porous throughout. Aluminum is a dangerous metal in the brass foundry; therefore great care must be exercised that none may get into the mixture. A very small percentage of aluminum will cause the castings to leak, although they may appear to be solid. Antimony and iron have a similar effect in a smaller degree.

* * *

No employer in Great Britain can have in his employ an enemy alien except under license. Except for Belgian refugees, there are very few alien workmen in England.

## PASS LIMITATION IN ROLLING MILL PRACTICE

BY ALFRED MUSSO [1]

The principal aim of the rolling process, undoubtedly, is to attain the greatest reduction of the cross-sectional area of the part being rolled that is consistent with the quality of the finished product. The reduction of the piece depends upon several elements, which can be grouped into two classes. To the first class belong all elements concerning the piece itself, and this includes all data referring to its size, the nature of the metal it is made of and also its condition while being rolled. To the second class belong all elements concerning the rolling mill, such as its dimensions and power. The scope of this article is to show some of the mechanical relations existing between the different elements mentioned and how they control the reduction of the piece.

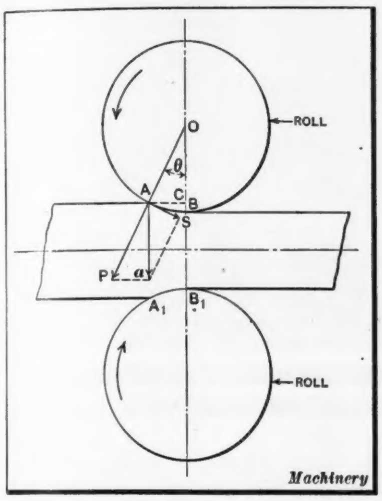



Diagram showing Relation between Rolls and Stock being rolled

Let us consider a vertical cross-section through the rolls of a rolling mill as represented in the accompanying illustration. The thickness of the piece while passing through the rolls is reduced from its original value $AA_1$ to the new value $BB_1$. We will call $BB_1$ the "pass." Evidently, $AA_1 = BB_1 + 2CB$, but $CB = OB - OC$, and $OC = AO \cos AOC$; then the first equation becomes:

$$AA_1 = BB_1 + 2(OB - AO \cos AOC)$$

Assume that:

$AO = OB = R$, radius of roll;
$AA_1 = T$, original thickness of piece;
$BB_1 = p$, pass; and
$\theta =$ angle $AOC$.

The last of the preceding equations may now be expressed as follows:

$$T = p + 2R(1 - \cos \theta) \quad (1)$$

This is the fundamental equation of the mechanics of rolling mills. Now, by assuming the width of the piece to be unity, the values of $T$ and $p$, for all practical purposes, will represent the sectional areas before the piece has entered and after it has left the rolls. This is in harmony with actual rolling mill practice. Equation (1) arranged in the form:

$$T - p = 2R(1 - \cos \theta)$$

shows that the reduction of the piece is a function of the angle $\theta$. This angle, called the "approach of the piece to the rolls," or, more simply, the "approach," is the controlling element in the relations between the dimensions of the piece and those of the rolling mill.

An inspection of the illustration, as well as proper transformations of Equation (1), show that for a given value of $T$ the value of $p$ will decrease, while that of $\theta$ increases, and *vice versa;* also, if the value of $p$ is given, the value of $T$ will increase with that of $\theta$. These facts may be embodied in the following statement: For a known size of rolls, the approach is directly proportional to the original thickness of the piece and inversely proportional to the pass. Considerations beyond the limits of this article show that the value of $\theta$ should not exceed 30 degrees, and in actual practice such a value is never reached. We will now establish the relations between the properties of the piece and its approach, which will enable us to find the proper value of the pass, consistent with the economy of the rolling mill output. Let us assume the following notations:

$a =$ normal pressure on piece;
$f_s =$ allowable unit shearing stress for piece;
$p =$ pass;
$P =$ radial pressure of roll;
$R =$ radius of roll;
$S =$ tangential shearing force;
$T =$ original thickness of piece;
$\theta =$ approach.

Evidently,

$$S = a \sin \theta$$

But

$$a = P \cos \theta$$

Then,

$$S = P \sin \theta \cos \theta = 1/2 P \sin 2\theta$$

The last equation shows that $S$ is also a function of $\theta$, and because $P$ is constant, and depends upon the dimensions and power of the rolling mill, it is evident that the ratio of $S$ and $\theta$ is also a constant. This enables us to regard the above equation as suitable for any value of $\theta$. Introducing the properties of the piece, we must have $\frac{S}{T} \leqq f_s$; then, selecting the highest safe value, *viz.*, $\frac{S}{T} = f_s$, which is consistent with good practice, the last equation becomes:

$$S = f_s T = 1/2 P \sin 2\theta, \text{ and, consequently,}$$

$$\frac{2 f_s T}{P} = \sin 2\theta \quad (2)$$

With the help of a table of sines, we will be able to find the value of $2\theta$, and, of course, of $\theta$. The latter value substituted in Equation (1) will determine the value of $p$ as follows:

$$p = T - 2R(1 - \cos \theta)$$

The value of $p$ thus found is the minimum safe pass which can be set in the rolls, and indicates the maximum safe reduction of the piece. As a practical application of the preceding formulas, assume that a band of 0.20 per cent carbon steel, having a thickness of No. 16 Birmingham wire gage (B. W. G.), is put through a cold-rolling process in a 10-inch strip rolling mill, driven by a 70-horsepower motor at 50 revolutions per minute. The efficiency of the mill is 40 per cent. The problem is to determine the pass. From the data given, the radial pressure at the rolls is first determined.

$$P = \frac{0.40 \times 70 \times 12 \times 33{,}000}{10 \times 3.14 \times 50} = 7061 \text{ pounds}$$

The value of $f_s$ for a 0.20 per cent carbon steel can be assumed at 6000 pounds per square inch. Then arrange the data as follows:

$f_s = 6000$ pounds per square inch;
$P = 7061$ pounds;
$R = 5$ inches;
$T = 0.065$ inch.

Substituting these values in Equation (2), we find:

$$\text{Sin } 2\theta = \frac{2 \times 6000 \times 0.065}{7061} = 0.11046$$

By referring to a table of sines, we find that $2\theta = 6$ degrees — 20 minutes; therefore, $\theta = 3$ degrees — 10 minutes, and $\cos \theta = 0.99847$. By substituting these values in Equation (1):

$$p = 0.065 - 10\,(1 - 0.99847) = 0.0497 \text{ inch,}$$
or approximately 0.050 inch

This shows the maximum reduction consistent with safety to be $T - p = 0.015$ inch, or 23 per cent of the original thickness of the piece. This result is corroborated by actual results in everyday practice.

* * *

During 1917, the total cost in the state of New York of "workmen's compensation," including the expense of administration, was $35,000,000, or $117,000 a day. Seven out of every ten applicants for compensation could not speak English. In Pennsylvania last year, $7,161,094 was awarded in compensations, an increase of $2,936,219 over the year before. In Massachusetts, there was paid as compensation about $5,000,000, against $1,667,000 in 1913. Part of this increase is attributed to the increase of the maximum award from 50 to 66 2/3 per cent of the wage.

[1] Address: Care of Crucible Steel Co. of America, Atha Works, Harrison, N. J.

# Manufacture of the U.S. 75-Millimeter Shell

*Second of a Series of Articles Describing Approved Methods Employed by the American Shell Co. in the Making of U. S. Ammunition — By Erik Oberg*[1]

IN the article in the March number of MACHINERY, the general lay-out of the plant of the American Shell Co., Paterson, N. J., was described; the order of the operations embodied in the company's practice was given, together with illustrations showing the shell after each operation, and the methods used in machining the work were reviewed up to and including the nosing or bottling of the shell. In the present article, the heat-treatment and the operations that follow the hardening and tempering operation will be dealt with.

### Heat-treatment

The heat-treatment consists of hardening and tempering the shells. Two hardening and two tempering furnaces are used. The hardening furnaces, shown in Fig. 1, are each provided with eleven tubes passing entirely through the furnace, these tubes consisting of 3½-inch pipe. The shells are fed into the tubes from one end, and in passing through the furnace are actuated by an automatic timing device which permits each shell to remain within the heating zone for sixty minutes. The inclined roller conveyors in the front carry the shells down to the opening of the furnace tubes. Above these are seen the hydraulic cylinders from which the mechanism for pushing the shells through the tubes is actuated, this mechanism, in turn, being controlled by a timing device which consists of the mechanism shown in Fig. 2. Pulley $A$ makes 300 revolutions per minute, and planetary gearing is provided at $B$, the reduction of this being as 1 to 1000; hence, the slow-speed hollow shaft $C$ makes 0.3 revolution per minute. A camshaft is driven from this slow-speed shaft by means of a silent chain from sprocket $D$. On the camshaft are eleven pairs of cams, which, in turn, operate eleven double-action pneumatic valves which control the hydraulic cylinders, the pistons of which push the shells through the furnace. A diagrammatical view of the mechanism for pushing the shells into the furnace tubes is shown in Fig. 3. The shell, resting on the rollers, is pushed forward by the pawl $A$ acting against the edge of the shell, as indicated, whenever pressure is admitted back of the piston $B$ through the action of the timing mechanism.

At the back end of the furnace (at the end of each pipe) is a door opening into a kind of an ante-chamber. The door opens only as the shells are pushed through the furnace, and closes after them. The shells then move forward by gravity and open a second door between the ante-chamber and the oil tank into which they drop. The ante-chamber makes it possible to retain the heat in the tubes and prevents the outside air from striking the shells. The furnaces are oil-fired, the temperature in the furnaces being 1600 degrees F., and that of the shells, about 1500 degrees F.

When the shells drop into the oil tank, they fall onto

Fig. 1. Hardening Furnaces provided with Automatic Pusher Feed, regulating Time Shells are in Furnace

[1] Editor of MACHINERY

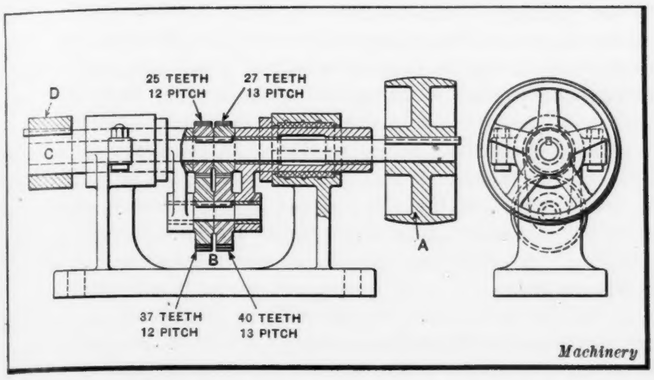



Fig. 2. Timing Mechanism which controls Pusher Feed for Shells

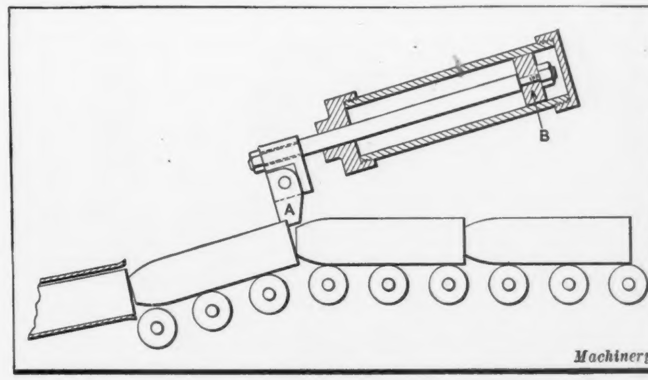



Fig. 3. Diagrammatical View of Hydraulic Pusher Feed

a link-belt conveyor, which moves them up an incline, where they drain, and then deposits them in a draining tank for further draining of the oil. The quenching oil is cooled off by passing through a series of coils in a water tank, shown in Fig. 4, located behind the nosing-in presses.

From the draining tank, the shells are taken by a gravity conveyor to the tempering furnace, which is similar to the hardening furnace, the only difference being that, instead of passing through tubes, the shells in this furnace are conveyed in chutes, so that the flame from the oil burners heats the shells directly. The temperature in the tempering furnace varies from 1100 to 1300 degrees F., according to the quality of the steel. The higher the carbon content of the steel, the higher the tempering temperature. Each shell remains twenty-five minutes in this furnace. At the back of the tempering furnace, two automatic conveyors, running toward each other, discharge the shells onto a third conveyor, which carries them into the cooling space. The conveyors at the back of the tempering furnaces are so timed that two shells are never placed upon the third common conveyor at the same time. At the end of the conveyor in the cooling space, there is a swinging chute, which makes it possible to discharge separate heats in separate piles.

After the cooling, tests are made in order to determine whether the shells are of the proper physical characteristics and whether the proper heat-treatment has been given to the steel. Test pieces are prepared from two shells out of each lot of 1000, for making tensile tests. Scrap shells are passed along with the others for this purpose. Brinell tests are also made on 10 per cent of the shells. The details of these tests will be given in a subsequent article.

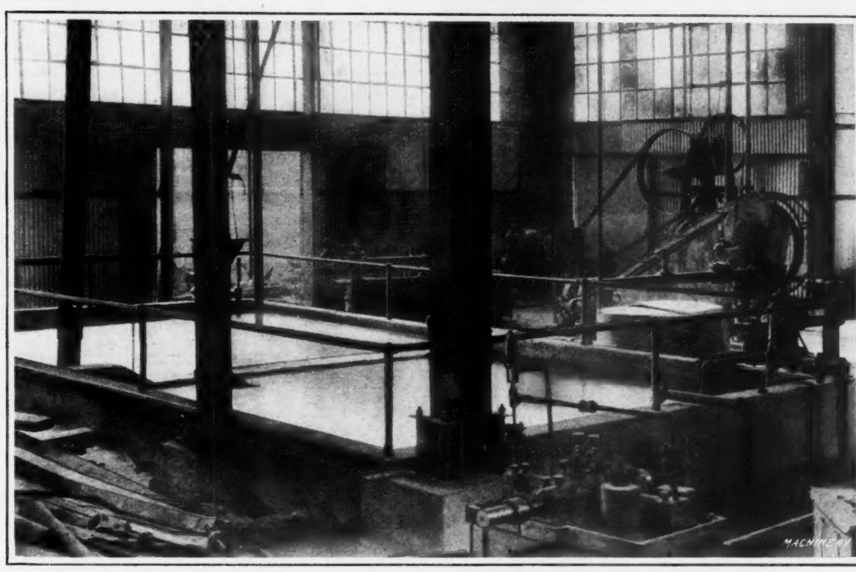


Fig. 4. Cooling Tank for Quenching Oil used in hardening Shells—Oil passes through Pipe Coils in Water Tank

### Machining Operations after Heat-treatment

The first machining operation after heat-treatment is to finish the base and under-cut the boss for the center. This under-cutting serves the purpose of making it possible to shear off the center in a later operation. The work is done on a Gisholt lathe, and a regular round-nosed tool is used both for the facing and under-cutting.

The hole for the fuse is now bored, recessed, faced, and beveled at the end. This work is done on a Potter & Johnston semi-automatic machine. Special tools are used only for the recessing operation, the tool used being shown in Fig. 5, where the recessing tool proper is shown at *A* mounted in a slide *B*. A stop or straight cam surface on the cross-slide acts against the roller *C*, thus moving the recessing tool in a transverse direction against the pressure of spring *D*. The tool then cuts a recess in the bore at the under side of the thread, which serves the purpose of clearing the milling cutter when the thread is cut. Screw *E* acts as a stop.

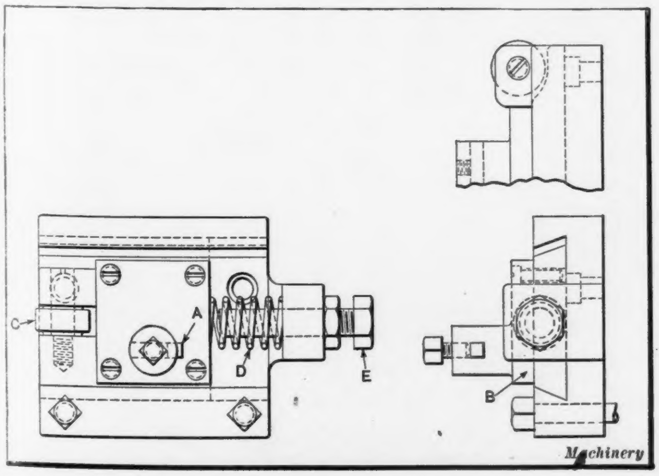



Fig. 5. Recessing Tool that is used for cutting Clearance for Thread Milling Cutter

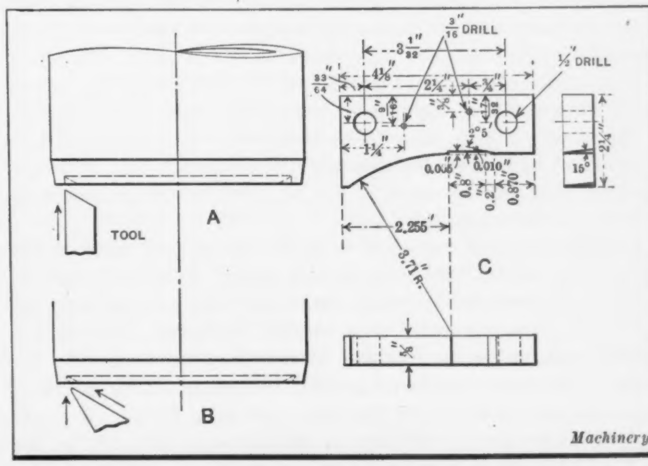



Fig. 6. Method of cutting Groove for Brass Plate, and Detail of Forming Tool used for finishing Nose

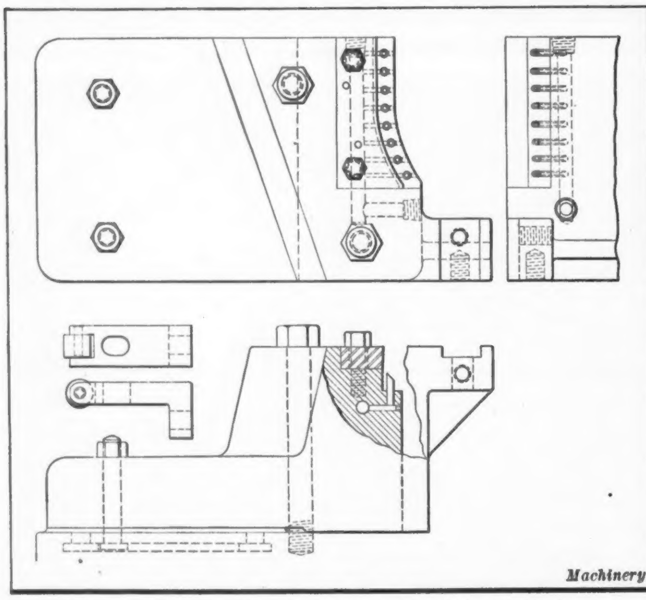



Fig. 7. Holder for Forming Tool which finishes Shell Nose

The rough-grooving for the copper band is done in a Wood turret lathe, a plain straight tool with a flat end being used. The groove is finished in the same type of machine, but a circular forming tool is used in this case, which produces the thread in the bottom of the groove. By presenting a knurl with straight teeth to the bottom of the groove which contains this thread, a very coarse, prominent knurling is provided to bind the copper band. The knurling is done in the same type of machine as is used for the cutting of the groove. The knurl, shown in Fig. 8, is made from high-speed steel on account of the heat developed in the knurling operation, it having been found that carbon steel will not meet the requirements. The knurls are cut in the shop on a Bilton automatic gear-cutter.

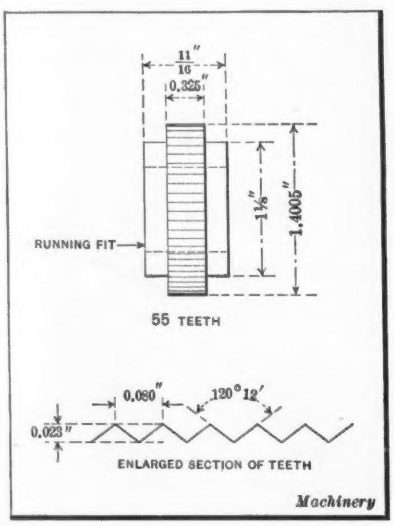



Fig. 8. Knurl used for knurling Copper Band Groove

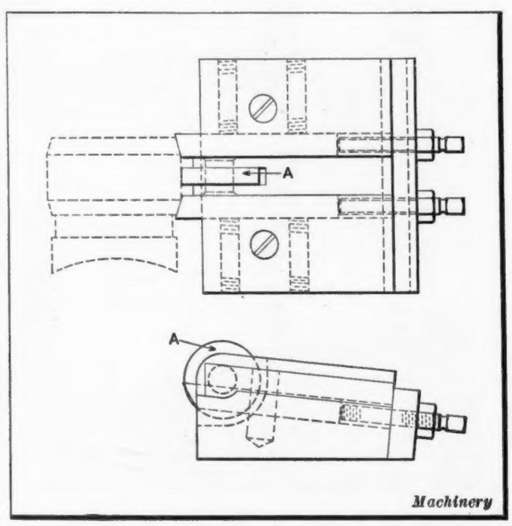



Fig. 9. Tools and Holder used for beveling Shell Body below Copper Band

The rough-turning of the nose is performed in a Gisholt machine with a regular four-tool forming head. The finish-turning of the nose is done on the same type of machine, but, in this case, a finishing profiling tool, 4 inches wide, held in a holder, as shown in Fig. 7, is employed, this tool giving the nose the correct shape. Eight oil-tubes located at the edge of the forming tool, as indicated, supply lubricant to the tool. The forming tool is shown in detail at *C* in Fig. 6. The body is now finish-turned above and below the groove for the copper band, an expanding mandrel holding the work by that part of the bore which is later to be threaded. The machine used is provided with a special air-operated centering cup, which is used for holding the work at one end, while a regular center is used on the other end.

A slight bevel is next cut at each end of that part of the body which comes below the copper band. The bevel next to the base is provided in order that the shell may be inserted easily into the cartridge case, while the bevel next to the copper band is for the purpose of crimping the case onto the shell. This operation is performed in engine lathes provided with special tool-blocks of the type shown in Fig. 9. A roller at *A* acts as a stop by coming in contact with the body of the shell. The work is held by a cup-center at one end and by an air-operated tail-center at the other.

The grinding of the bourrelet is done in the grinding machines shown in Fig. 10, especially built for the purpose. The shells are fed transversely toward the wheel only, the wheels being wide enough to grind the whole surface at once. The amount of feed to obtain the correct diameter is shown by a graduated indicator on the machine, which is set each time the wheel is trued. The wheels are trued frequently in order to make sure that the wear of the wheel will not affect the accuracy of the grinding. The shells are held for this operation by a cup-center at one end and an air-operated tail-center at the other.

All of the operations that need to be performed on centers are now completed, so the center at the base is removed by shearing. A power press is used for this purpose, provided with two shear blades, very similar in operation to a sprue cutter. These blades are made from carbon steel, as high-speed steel has no advantage for this purpose; in fact, high-speed steel will not give as good service as carbon steel for this work, as not enough heat is produced in the operation to develop the qualities that make high-speed steel superior to carbon steel. After having sheared off the center, the base is faced in a Gisholt machine by an ordinary high-speed steel facing tool.

The groove in the base for the brass cover is now cut. The base cover is inserted to prevent a possible premature explosion due to ignition of the charge in the shell from the charge in the cartridge case, through a "pipe" in the center of the base of the shell. This groove is cut in two operations, two Oliver lathes being used. In the first lathe, a tool as indicated at *A*, Fig. 6, cuts a plain groove; in the second lathe, a tool as indicated at *B* is used, which is set at an angle. This tool is also fed at an angle, and thus produces the under-cut which is required to bind the brass cap securely in place. The thread for the fuse is now cut. A Lees-Bradner thread milling machine is used, provided with an air-operated collet. The cutter shown in Fig. 13 is first fed into the hole to the correct depth, and

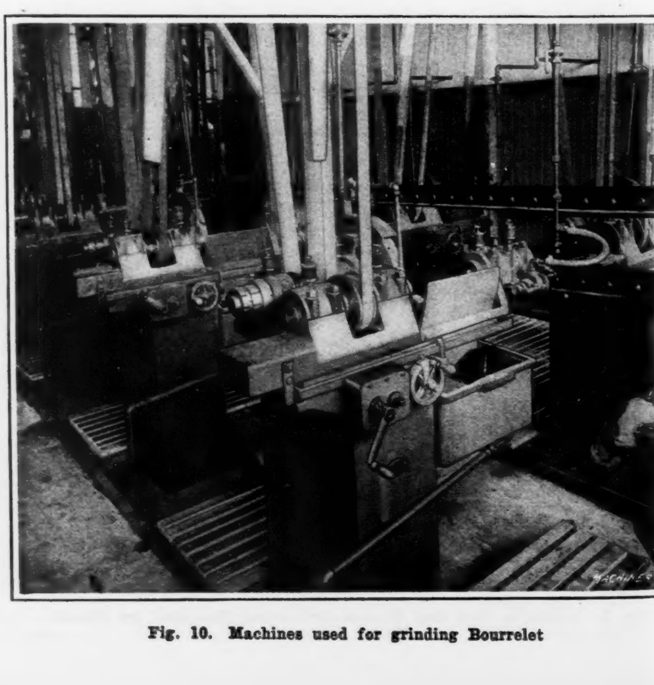


Fig. 10. Machines used for grinding Bourrelet

is then fed sidewise until the proper depth of thread has been cut, after which the shell is rotated about one and one-half times around to cut a complete thread. There are twelve threads per inch of a modified U. S. standard, the top being a sharp vee, while the bottom has the U. S. standard flat, as indicated in the enlarged view of the thread. While the operations call for sizing the threads after milling, it has been found that they are generally so perfect when leaving the milling machines that no further tapping operation is required. Once in a while, a shell that may not have a perfect thread is sized on a separate machine with a sizing tap. An ordinary drill press is used for this purpose, provided with an Errington automatic tapping chuck and a pneumatically operated vise.

From the thread milling machines, 10 per cent of the shells pass to the hydraulic testing press, where they are subjected to a test which indicates the elastic limit of the shell. Details of this test will be given in a subsequent article. The shells that have been hydraulically tested are then passed back to the drill press, where the thread is sized, as the hydraulic test slightly alters the accuracy of the thread.

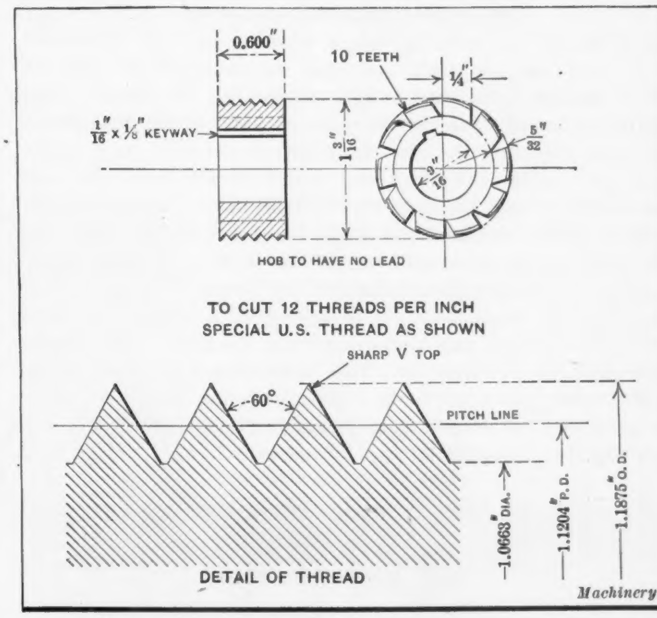


Fig. 13. Detail of Milling Cutter or Hob for milling Threads for Fuse

### Automatic Notching Machine

The shells are now provided with a small notch at the open end for the detonator. This notch is cut by a full-automatic notching machine built by the company, which takes the shells from a gravity conveyor and deposits them onto another conveyor after the notch has been cut. This machine is shown in Fig. 11. The milling cutter which cuts the notch is shown at *A* and the shell operated upon at *B*. The shells are automatically clamped and fed forward to the cutter. As the shells are fed by the gravity conveyor to the machine in one continuous flow, it is necessary to clamp not only the shell being operated upon, but also the next succeeding one which has just passed off from the conveyor, so that the shells behind the one operated upon will not press that shell forward or interfere with the proper operation of the machine. The next succeeding shell, therefore, is shown automatically clamped at *C*, while the other shells on the conveyor back up against the end of this shell. When the shell operated upon has been discharged, as will be described later, clamp *C* is released by the action of cam *D*, and is pushed forward by the weight of succeeding shells until it comes into position *B* against stop *E*. Clamp *F* then grips the shell by the action of cam *G* and toggle joint *H*. The axis of the cutter-spindle is stationary, and the shell is fed forward to it by the motion of the shell carriage, which is operated by means of a crank and pitman *J* and *K*, the crank being driven through a bevel gear, worm, and worm-wheel from the main spindle. Shaft *M* also carries a bevel gear, which, in turn, drives the transverse spindle that operates the clamping mechanism through a series of bevel gears, thereby assuring a proper sequence of operations with regard to the release of the clamps.

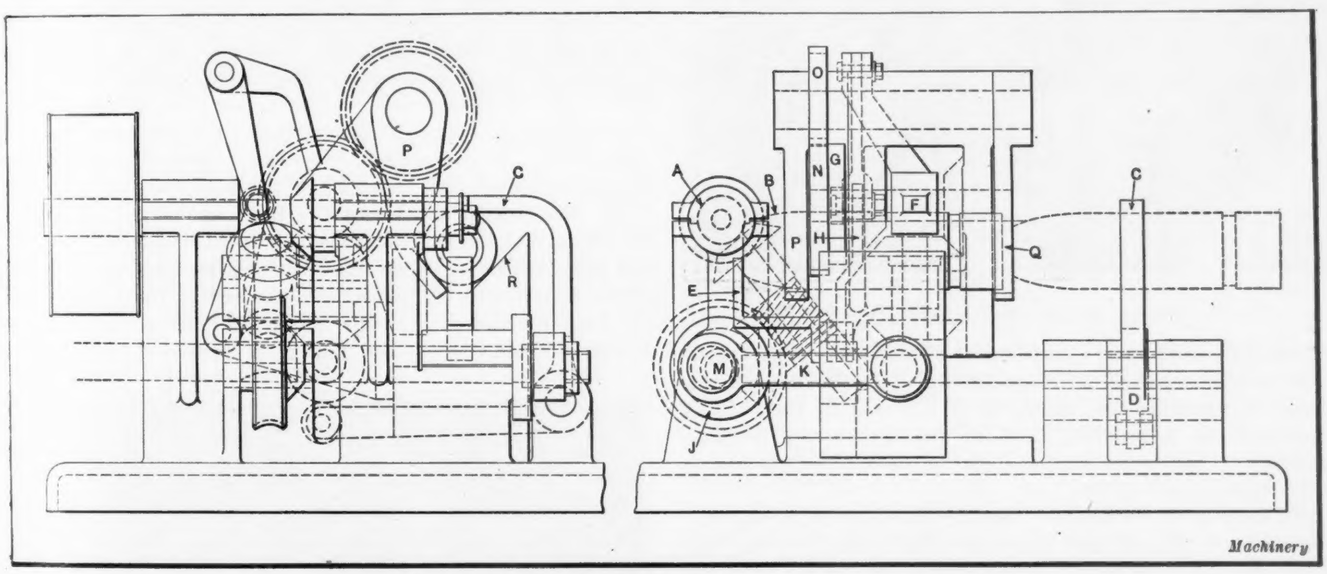


Fig. 11. Automatic Machine for notching Shells for Detonator

The discharging mechanism is carried by a shaft driven by the gears *N* and *O*, which are part of the clamping mechanism. These gears continuously rotate arms *P* and *Q*, which come around once each time a shell is ready and which push it up an incline *R* and onto the conveyor. Previous to the use of this automatic machine, the shells were notched in a small standard milling machine, the shells being laid in a V-block.

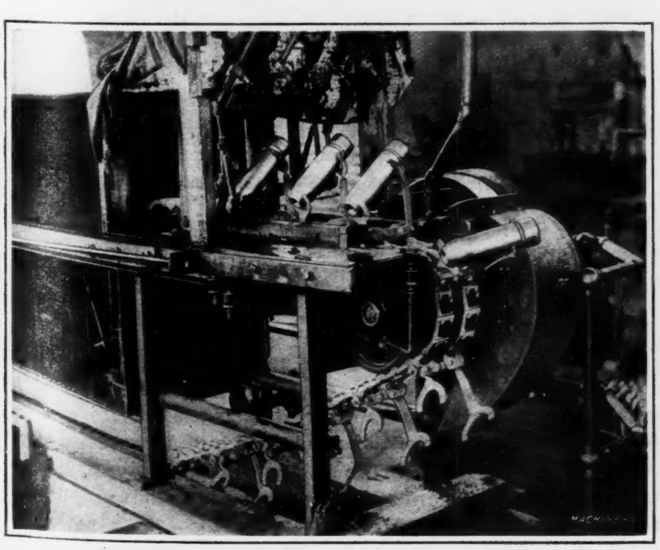


Fig. 12. Shell Washing Machine

### Final Operations and Inspection

The shells now pass through a washing machine consisting of a long, endless chain conveyor, as indicated in Fig. 12, which carries them into a tank containing hot oakite. The shells are placed upon the conveyor by hand at the end shown, and then pass into the tank indicated to the left, from which they pass out at the other end, which is similar to the end shown, and where they are removed by hand. The shells are held in an inclined position while passing into the tank, and are simultaneously sprayed on the inside by a solution which is forced into them from nozzles placed beneath them. After washing, the whole shell is inspected at a long table, each inspector checking one dimension only, the shell being passed from inspector to inspector. This inspection is repeated in the government inspection room, after which the shell returns to the shop and the copper band is put in place in West tire setters, Fig. 14. The regular type of machine is used, except that

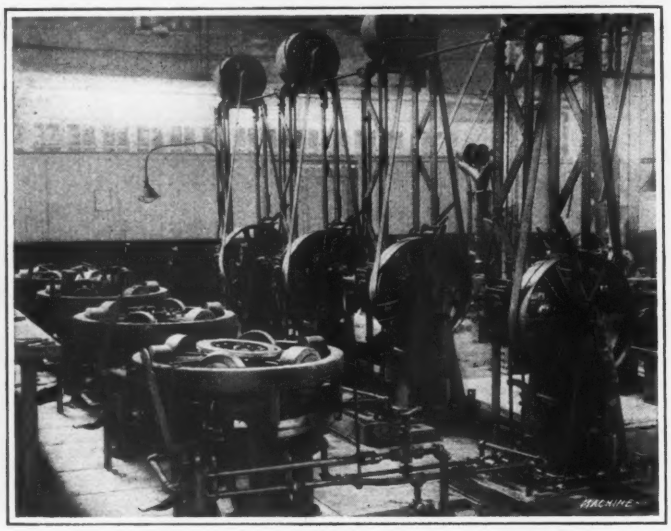


Fig. 14. Machines used for pressing Copper Band into Place

the ordinary jaws are replaced by tool-steel jaws. The copper bands are next turned in a special American Shell Co.'s machine. A roughing tool is placed in a holder on the turning machine, and a finishing tool of the under-shot forming-tool type is used on a lever-operated cross-slide. This tool is of the form shown in Fig. 15.

The shell is now ready for putting the brass plate onto the end. A lead plate is first attached to the base by petroleum jelly; then the brass plate is dropped in place and the shell put under a press provided with a special punch or die, which forces the brass plate into position. The punch or die is compounded, having an inner die which holds the plate in position while the outer part crimps the edge of the groove cut in the shell base over the plate. This die is shown in Fig. 16. A small 40-ton hydraulic press is used for this operation. After the final government inspection, the shells are numbered in a Dwight & Slate numbering machine, being laid in a cradle consisting of two rollers, after which the eccentric marking wheel is forced down upon them.

The lacquering on the outside of the shells is done in the machine shown in Fig. 17, especially built for the purpose. The shells are placed upside down on studs attached to a moving link-belt. At a certain point in their travel, the shells strike rollers which force them to rotate. At this time, the operator directs the spraying gun onto them, thus covering them completely with lacquer. The shells then automatically move into a drying oven, from which they pass out at the other end, where they are removed. The inside is then sprayed by hand; no special drying means are provided after this spraying. This finishes the operations upon the shells before they are ready for shipping.

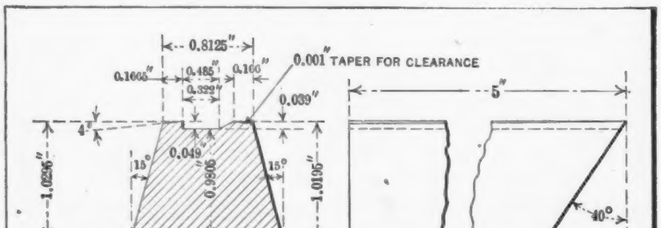


Fig. 15. Forming Tool for finishing Copper Bands

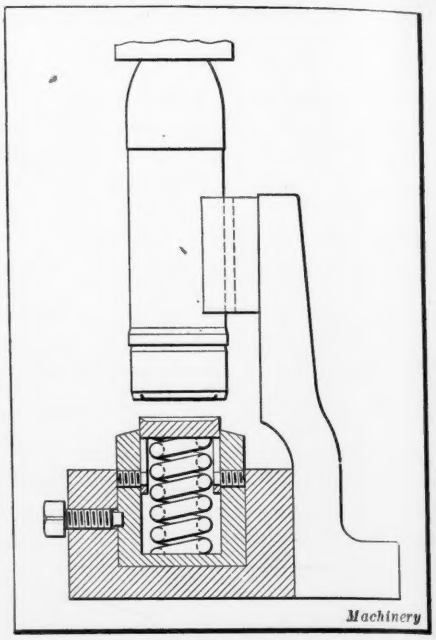


Fig. 16. Die for pressing Brass Plate onto End of Shell

### Employment of Women in Shell Work

The American Shell Co. employs a large percentage of women on the manufacture of the 75-millimeter shell. Women are employed not only on inspection operations and such work as in the past was ordinarily performed by women operators, but also on a great many of the machining operations. It is stated that the work done by the women is very satisfactory. The operations performed by women in the making of the shell are as follows: second rough-turning of entire outside, together with inspection; all government inspection; Brinell test; boring, recessing, facing, and beveling of the hole for the fuse, with inspection; finish-turning of the body above and below the groove for the copper band, together with inspection; beveling the body of the cartridge case, with inspection; the grinding of the bourrelet, with inspection; the cutting of the groove in the base for the cover, with inspection; the milling and inspecting of the thread; the final shop inspection of the whole shell; the final government inspection; the inspection of the copper band; the assembling of the base cover; and the pressing of the base cover into place.

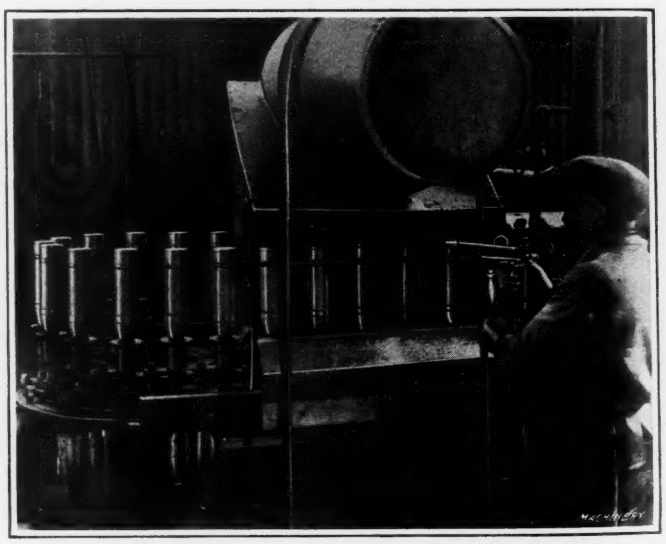


Fig. 17. Machine for varnishing Shells on Outside

* * *

Owing to the lack of workmen's houses, the British Government has decided to erect from 150,000 to 200,000 dwellings. While these houses will be standardized, there will be slight variations in dimensions and style in different localities. Where conditions permit, the cultivation of gardens will be encouraged. A standard system of planting is advocated, the number of houses not to exceed twelve for each acre. The width of arterial roads will be 100 feet, secondary roads, 50 feet, and residential roads from 36 to 40 feet.

# PROJECTION METHOD OF TESTING SCREW THREADS[1]

### ARRANGEMENT AND USE OF PROJECTION APPARATUS AS APPLIED TO INSPECTION OF THREAD GAGES FOR MUNITIONS MANUFACTURE

BY FRANKLIN D. JONES[2]

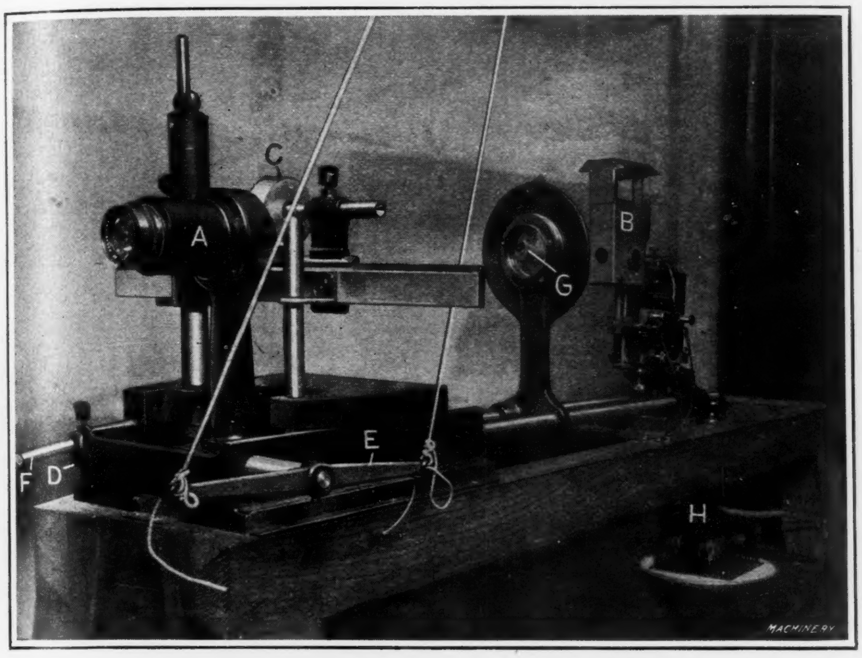



Fig. 1. Projection Apparatus for testing Screw Threads

CONSIDERABLE progress has been made in the development of apparatus for detecting inaccuracies in screw threads, especially during the past three years, because of the tremendous amount of screw cutting necessary in connection with munitions manufacture and the great importance of maintaining the screw thread dimensions within the limits prescribed. Different types of gages and precision measuring machines have been improved in design and new forms of apparatus originated. A modern and very effective method of testing screw threads is by the use of an optical projection apparatus. The principle is very simple: An image of the thread is projected upon a suitable screen and is then compared with the profile or outline of an accurate thread of standard proportions. It is necessary, of course, to determine previously the magnification or the extent to which the thread under observation is to be enlarged upon the screen, so that the profile or thread outline used as a standard in making comparisons may be drawn to a corresponding scale. This projection method shows errors in the pitch, angle, or form of the thread, and it is especially valuable for testing the shape of a Whitworth thread.

#### Optical Projection Apparatus

The projection apparatus to be described was developed by the National Physical Laboratory of England and is employed in conjunction with other precision measuring machines for verifying the accuracy of inspection gages. This work of gage inspection, for the plants in this country manufacturing munitions for the British Government is carried on under the direction of H. J. Bingham Powell, inspector in charge of the Department of Gages and Standards of the British Ministry of Munitions of War in the United States. The apparatus will first be described and then some examples illustrating its practical application will be referred to.

Two views of the apparatus are shown in Figs. 1 and 2. There is a projection lens at *A*, an arc light at *B*, and adjustable conical centers at the rear of the lens for holding the gage *C* to be examined. Just beneath these centers there is a clamp which may be used for holding any gage or other part that cannot readily be mounted between centers. The slide which carries the work-holding clamp and centers may be adjusted along its base, thus varying the distance between the object to be projected on the screen and the lens. The purpose of this adjustment is to obtain the proper focus. The focussing slide is attached to a rod *F* which connects with a small eccentric at *D* mounted on a shaft carrying the double-ended lever *E*. The focus is first adjusted approximately by unclamping the slide from the rod and moving it along the base, and lever *E* is then used to obtain the fine adjustment. This lever has cords attached to it so that adjustments may be made from the screen where it is possible to see more clearly just when the focus is correct.

It is very essential to provide for this apparatus a lens of good quality and one that has been corrected for distortion to secure an accurate reproduction of the thread profile on the screen. A strong source of light is also necessary, so that a clear and sharply defined outline or shadow will be projected. The carbons of the arc light used with this apparatus are located 90 degrees apart instead of being placed one above the other. With this arrangement the crater or concave depression which forms in the end of the positive carbon is pointed directly toward the lens; consequently, a maximum amount of light is reflected and shadows of the crater wall or edge are not projected upon the screen. When one carbon is placed above the other, the formation of the arc at dif-

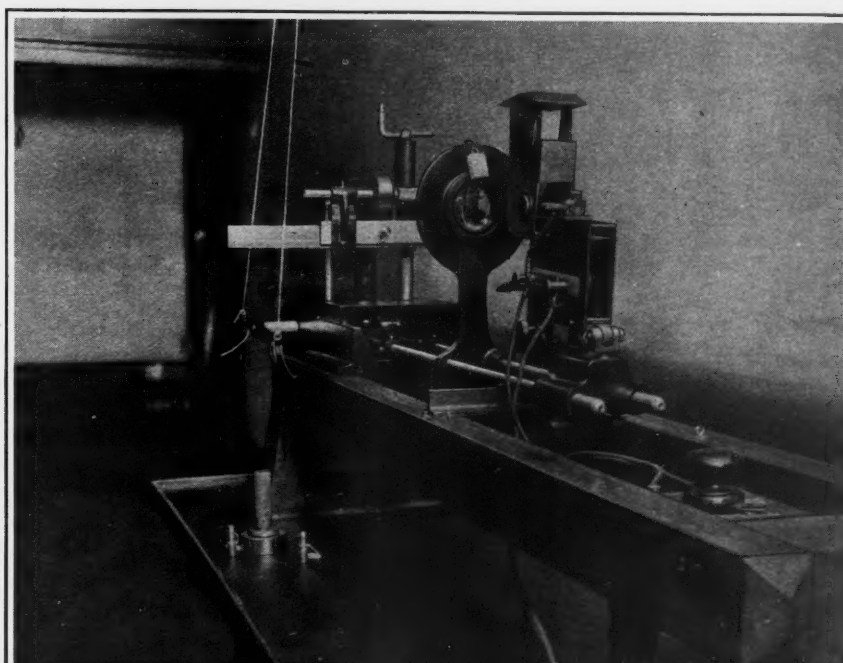


Fig. 2. Rear View of Projection Apparatus, showing Screen in Background

[1] For other articles on thread testing, see "Precision Screw Testing Machine," February, 1918; "Inspection of Screw Gages for Munitions of War," January, 1918; "Gaging Systems for Screws and Taps," July, 1917; and "Gaging and Inspecting Threads," February and March, 1917.

[2] Associate Editor of MACHINERY.

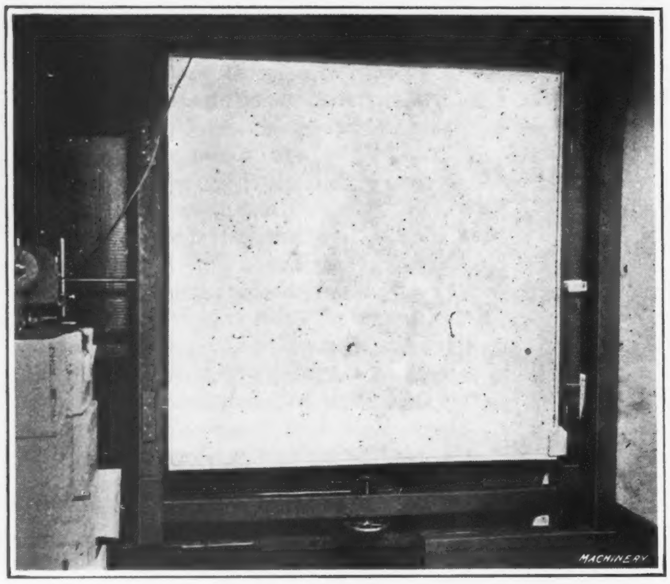


Fig. 3. Screen upon which Screw Threads are projected

ferent points around the edge of the crater sometimes results in casting a shadow of the crater wall upon the screen, thus interfering with the image of the part under observation.

The projection apparatus referred to is arranged for a magnification of 50, the thread section being enlarged that number of times, which enables even slight inaccuracies to be observed readily. The magnification may be verified before testing a screw thread by placing between the centers back of the lens a cylindrical part such as a plug gage, and then adjusting the focal distances until the shadow upon the screen is of the required size as determined by measurement. The focal distances mentioned are the distances between the screen and projection lens and the distance from the screw to the projection lens, the measurements in each case being along the line of projection.

Between the lens and the arc light there is a condenser or lens *G* which gathers the rays of light from the arc and changes their direction so that all the rays between the condenser and lens are parallel. These parallel rays are obtained by locating the condenser at the right distance from the arc. The axis of the gage or screw thread to be observed is located at right angles to the axis of the lens, so that the image projected on the screen represents an enlarged section of the thread in the plane of its axis, or in the plane in which the thread angle should be measured. As is quite apparent, if the gage were adjusted from this perpendicular position an amount equal to the helix angle of its thread, the projected image would represent a section normal or at right angles to the thread.

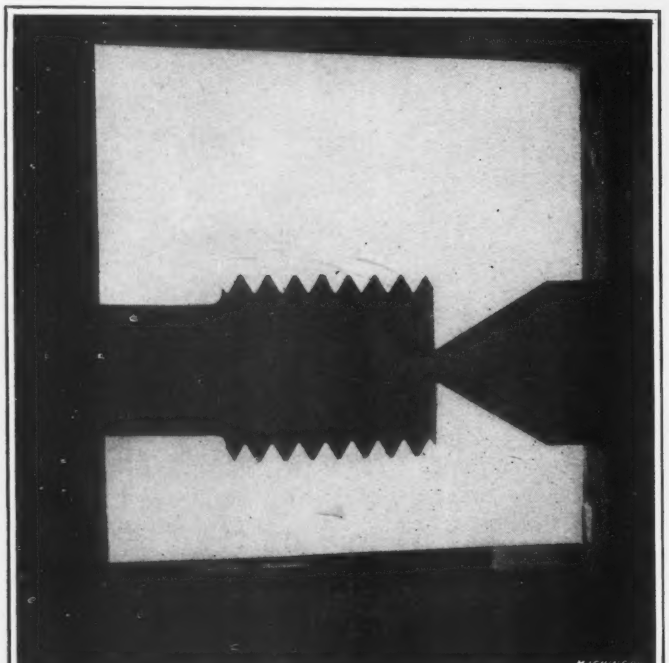


Fig. 4. Small Plug Gage projected upon Screen

In order to secure a clear, sharply defined projection on the screen, it is essential to have the light rays between the condenser and lens in line with the thread on the side that is to be observed and projected. This alignment of the light rays with the helix angle of the thread is of particular importance when the pitch is large in proportion to the diameter or when the thread inclines considerably relative to its axis. Therefore, the arc light and condenser are mounted upon a frame which is pivoted directly beneath the lens and is free to swing in a horizontal plane. When a gage is placed between the centers preparatory to projecting its image upon the screen, the frame referred to is adjusted until a well-defined projection is secured. The apparatus is connected with an ordinary 110-volt lighting circuit, but the voltage is reduced considerably by means of a rheostat *H*, Fig. 1.

### Screen upon which Thread Profile is Projected

The screen upon which the shadow or image of the thread is projected is practically a large drawing-board faced or covered with heavy drawing paper or bristol board. The particular screen seen in the background of Fig. 2 and also in


Fig. 5. Making a Cast of a Section of a Ring Gage Thread preparatory to testing by Projection Method

Fig. 3 is provided with rollers at the bottom and is mounted upon a horizontal track. The screen is also supported by a vertical screw, so that it may be adjusted either in a horizontal or a vertical direction for locating any standard thread outline which may be drawn upon the screen in coincidence with the projected image for observing any differences of form, angle, or pitch. This adjustable feature, however, is an unnecessary refinement, as it is much more convenient to have the standard thread outlines drawn on sheets of cardboard which are held against the screen in line with the projection when examining a thread.

Incidentally, it is important to locate the screen so that it is perpendicular to the line of projection, and in order to test its position the lens and any other part that may be in the

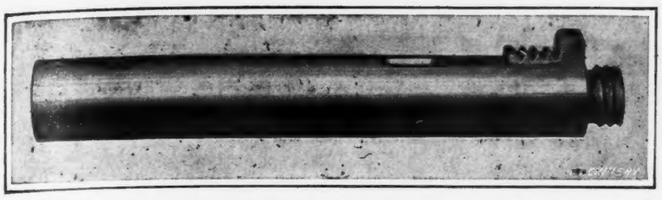


Fig. 6. Spindle containing Cast made as shown in Fig. 5

holder are removed. The parallel beam of light from the condenser then illuminates a small circle on the screen. A mirror is held against the screen in such a position that the beam of light is reflected back onto the apparatus. The screen slide is then adjusted until this reflected beam coincides with the projected beam, or until it passes back through the opening which ordinarily contains the projection lens.

### Testing Ring Gages by Projection Method

When the profile of a thread gage of the plug type is to be examined, the gage is placed between the centers back of the lens and the slide carrying these centers is adjusted vertically until the thread profile on the lower side of the gage is in line with the center of the lens. This vertical adjustment is, of course, necessary for examining gages of different diameters. The pivoted frame which supports the arc light and condenser lens is then swiveled in a horizontal plane as previously described, in order to align the light rays with the thread. The observer then goes to the screen and, after carefully adjusting the focus by means of the cords connecting with the apparatus, compares the projected image with a standard thread profile. A comparison with a standard thread outline will show readily minute errors of form as well as any appreciable inaccuracy of pitch or angle. A true form at the crest and root of a Whitworth thread is very important, except when clearance spaces at these points are provided, as, for example, in the case of plug gages of the type used for checking the effective diameter only of a ring gage. The nature of the errors detected by the projection method vary, of course, considerably. For instance, the radius at the crest or at the root may be incorrect, or if it conforms to the standard radius the rounded part may be off center relative to the remainder of the thread. All errors of this kind as well as any irregularity along the slope, or decided variation either in pitch or angle, are readily detected by the projection method. The illustration Fig. 4 is an actual photographic reproduction of the image of a small plug gage projected upon the screen. This gage is one of the small sizes shown in Fig. 2 upon the table which supports the projection apparatus.

When the angle of the thread is tested, a piece of cardboard is used upon which lines are drawn to the standard included angle of 55 degrees (Whitworth thread) and to several greater and smaller angles with variations of thirty minutes. An error of ½ degree may be detected easily by simply comparing the projected image with the standard referred to. An error in the pitch will be detected by a lack of coincidence of the successive threads of the image and standard thread outline, but it is not advisable to attempt to measure such differences since the scale of magnification is insufficient to obtain the result accurate to tenths of a thousandth of an inch, an error of 0.0001 inch in the gage being indicated by 0.005 inch on the screen with the 50 magnification used, which is a quantity too small for accurate measurement.

### Application of Projection Method to Ring Gages

When a plug gage is being examined, the profile of the thread is projected directly upon the screen, but obviously this method could not be employed when testing a ring gage, although the accuracy of the latter may easily be verified by the use of the projector. This is done by making a small cast of a section of the thread by using an appliance designed by H. J. Bingham Powell and patented in the United States. This cast or impression (which corresponds to a segment of a plug gage of corresponding diameter and pitch) is then mounted in the projector the same as a plug gage. The cast is made of a composition containing 93 per cent sulphur and 7 per cent graphite. This composition is poured into a mold formed by a slot in a spindle which is held against one side of the ring gage. Fig. 5 illustrates how a cast is made. The spindle *A*, which contains a slot and serves as a support for the cast, is screwed into baseplate *B* and is perpendicular to the surface of this plate. The ring gage *C*, the thread of which is to be examined, is held against the spindle by screw *D* and then the composition is poured into the mold thus formed, as the illustration indicates. A detailed view of the spindle with the cast in place is shown in Figs. 6 and 7. The latter illustration also shows the baseplate of the casting fixture and three cast segments which have been removed from the spindle to show clearly their form. The spindle and cast segment is placed between the centers of the projection apparatus, the same as though it were a plug gage. These casts taken from ring thread gages are also used in connection with the Bingham-Powell patented pitch-measuring machine, which was described in the January number of MACHINERY, page 452.

### Tracings of Inaccurate Thread Forms

In order to secure a permanent record of the thread outline, the edge of the shadow projected on the screen may be traced in pencil upon a sheet which is filed for future reference. These outlines are sometimes sent to gage-makers to show them the exact nature of the error or to manufacturers when the outline is of a thread on the product instead of a gage thread. Figs. 8 to 10, inclusive, show a number of these tracings which were obtained by means of the projection apparatus. The dotted line in each case shows the standard thread form, and the full line, the actual shape of the thread. The thread illustrated at *A*, Fig. 8, is on a plug gage intended for testing the fuse holes in the ends or noses of shells. This thread is accurate as to pitch, but the crest is flat instead of being rounded, whereas the root extends considerably below the dotted arc representing the correct depth and radius. The outline shown at *B* is the thread of a ring gage and was projected from a cast. In this case the pitch is also very accurate and the principal defect is at the root which has too large a radius, so that the sides of the thread are under-cut. Another ring gage thread is shown at *C*. The radius of the crest is small and the radius of the root large, the result being a thread that is too narrow. It will be understood that these thread profiles were not selected as typical examples of gage work, but merely to illustrate the nature of some of the common defects. Tracings are only made when the errors are sufficiently pronounced to require an investigation. Most of the gages examined conform more closely to the standard outline than is indicated by the examples shown in Fig. 8, but when the gage is sufficiently accurate to pass the inspection test, the outline is not traced, since there is no need of such a tracing.

Fig. 9 shows two examples of threads on the product or work. The upper view *A* illustrates the thread on a ¼-inch bolt forming part of an airplane motor. The actual thread form in this case deviates only slightly from the standard outline and this is regarded as a very good example of work. The other extreme is illustrated at *B*, which represents the

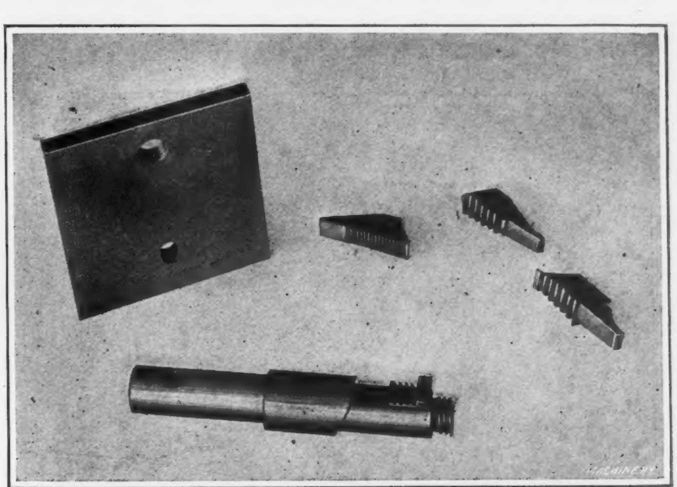


Fig. 7. Baseplate of Casting Fixture, Spindle, and Casts or Segments obtained from Ring Gages

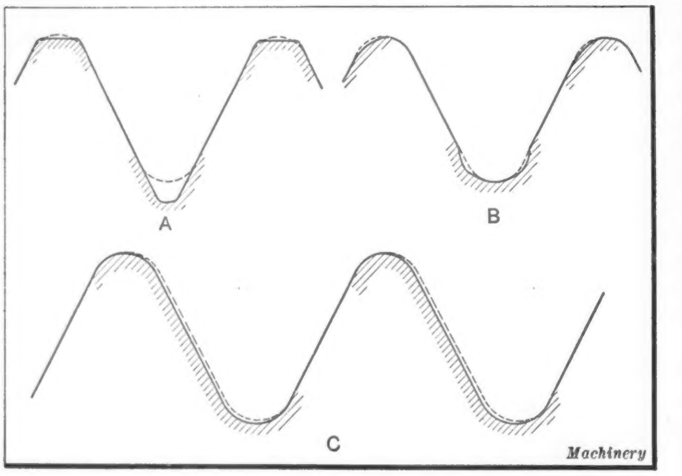



Fig. 8. Tracings made in Conjunction with Projection Apparatus which show Inaccuracies in Plug and Ring Gages

thread of a nut. This thread was supposed to conform to the British Association standard indicated by the dotted line, and it illustrates what it is possible for a tap to do when it is not in good condition or is improperly applied.

While the projection apparatus is of especial value for examining Whitworth threads, it may also be used to advantage in connection with the United States standard thread or any other form. Two tracings from United States standard threads are reproduced in Fig. 10. The outline shown at *A* was projected from a plug gage having eighteen threads per inch. The pitch of the thread is very accurate, but the top is a little too wide and the root is finished almost to a sharp vee. The thread illustrated at *B* was projected from a turnbuckle. There are thirty threads per inch in this case, and it is supposed to conform to the United States standard, although there is considerable deviation, as indicated by the full and dotted lines.

### Photographing Thread Forms

A photograph of the outline of a projected thread may be obtained without much difficulty instead of tracing the contour in pencil, although the latter method is simpler, more rapid, and less expensive. One method of securing a photograph is as follows: A part similar in form to the focussing bellows of a camera is attached in front of the projector lens and is arranged to hold a plate slide. The exposure is made either on a rapid plate or directly upon bromide paper. A ground glass screen is inserted in the plate slide prior to making the exposure and is used for focussing. For comparative purposes the outline of a standard thread form may be secured in conjunction with the photograph of the thread to be examined by first making an artificial negative. This should be a duplicate of the standard thread except that the outline is enlarged in proportion to the magnification of the projected thread image. A magnification of 20 is considered about right for making photographic reproductions. The artificial negative may be made by drawing as accurately as possible the thread contour on tracing paper. This outline, which should be twenty times the actual size of the thread, is next filled in with India ink to obtain a solid black thread section. Several coats of the ink should be applied, and to prevent the paper from wrinkling and buckling, it should be moistened before applying the ink and then be smoothed out thoroughly after the ink is dry by using a hot flat iron. This artificial negative is placed in contact with the sensitized plate preparatory to making the exposure and it serves as a standard for comparing the photographic reproduction with the actual thread. The artificial negative must be set so that it will be parallel and close enough to the projected image to enable the actual and true outlines to be compared readily.

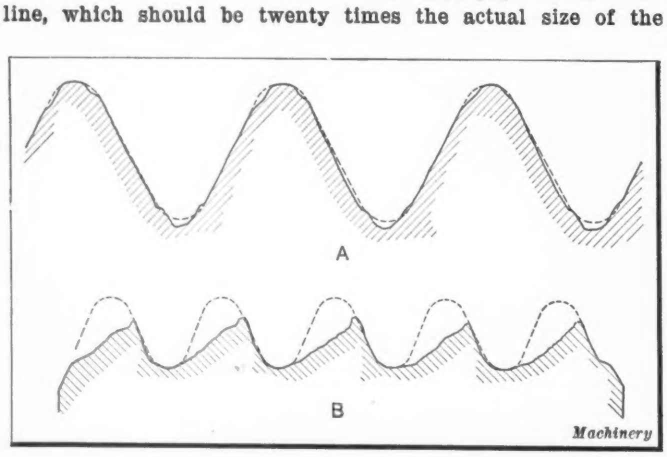



Fig. 9. (A) Tracing of Thread on Airplane Motor Bolt. (B) Thread supposed to conform to British Association Standard

The optical projection apparatus is not restricted in its use to testing screw threads, but may be employed to correct the accuracy of the profiles of gear teeth, the shapes of cams or gages of the contour type, or any other parts having an outline that may be projected and compared with a standard form.

* * *

## RIGHT- AND LEFT-HAND TOOLS

BY THOMAS FISH[1]

In the December, 1917, number of MACHINERY there appeared an article signed R. L. commenting on the writer's article entitled "Right- and Left-hand Tools" in the September number. R. L. states that he does not agree with the decision that we made in reference to the use of the terms "right-" and "left-hand" and "right-" and "left-bent," etc., and he is of the opinion that if several men who knew nothing of machines or tools were shown tools of various hands and bends their definition of the tools would coincide with his. The writer might agree with this statement, but he also has to agree with the other side. There are a good many who do not endorse the conclusions of the writer as stated in the September number, but these were based on a complete investigation which showed that the majority of the leading machine tool companies and mechanical engineers in this country used the terms given with the meanings stated. Our thought was that it would be preferable for us as manufacturers of tool-holders to coincide with the majority of the mechanical engineers, rather than try to force the majority to accept terms that we might believe in, but that did not conform with the general standard of opinion. What we would like to see brought about, however, is a general understanding as to the terms that are used and universal adoption of standard terms. We believe that this was covered in the article in the September number.

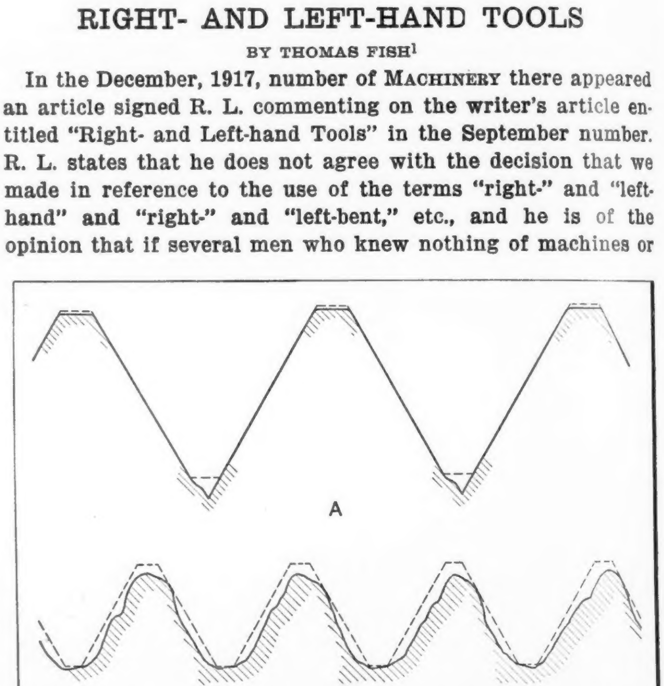



Fig. 10. Two Examples of Defective U. S. Standard Threads

* * *

On its trial trip, the *Namsenfjord*, the first reinforced concrete full-powered vessel, showed that it had excellent seagoing qualities and very little vibration. It will carry 200 tons of cargo at a speed of seven and a half knots. Although the hull is heavier than if made of wood or steel, the cost of upkeep will be practically nothing, and the cost of repairs, in case of accident, is greatly reduced. It is thought that this increased weight of hull will make possible the use of oil engines on tugs.

[1]President Ready Tool Co., Bridgeport, Conn.

# LETTERS ON PRACTICAL SUBJECTS

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## BORING ATTACHMENT FOR LATHE

A boring attachment suitable for use on any size lathe in shops where there are no boring mills or other machines, and where, occasionally, large pulleys and gears must be bored, can be made by any machinist possessing ordinary skill. The attachment shown in Fig. 1 was made in a shop that was equipped with an 18-inch lathe and a small planer. The writer made the patterns and did all the machine work, and the cost was covered in the first two jobs on which the attachment was used. In boring out two large pulleys there was an error of but 0.002 inch in six inches length, due, doubtless, to the fact that the cold-rolled shafting was not trued up after the keyway had been cut. This attachment was designed by the writer to prevent a shut-down.

The parts required are two cast-iron bearing standards, one of which is shown at *A*, the other being at the tailstock end of the lathe; a faceplate *B*, 22½ inches by 13 inches, with a 2½-inch hole in its center; an angle-plate and two braces *C*; a bearing plate *D* for the lathe carriage; two pieces of cold-rolled steel shafting, and some gears. The gears can be easily procured, if nowhere else, at any garage and sometimes they may be found in the junk pile of an automobile repair shop. Those used by the writer were taken from a discarded gear-case of a Buick car. They were bored out and then shrunk

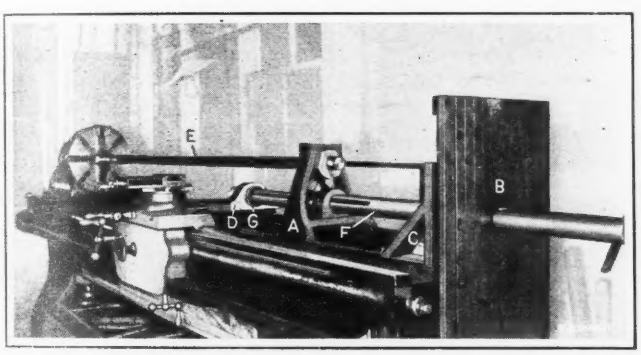



Fig. 1. Boring Attachment for a Lathe

over suitable bushings to receive the shafts and keys. The drive shaft *E* is made of 1 7/16-inch cold-rolled shafting and is long enough to reach from the chuck through the first bearing standard *A*. It is squared at the end that enters the chuck and a keyway is cut in the other end for the gear. The boring shaft *F* is made of 1 15/16-inch cold-rolled shafting and is about five feet long. One end has a ½-inch square hole for the boring tool; at the other end a 1-inch standard thread is cut for two inches. Then the shaft is turned to 1 3/16 inch for a distance of 3 3/4 inches, and a keyway ⅛ inch by ¼ inch is cut toward the center for a distance of 2 feet, 1 inch, or until it passes through the standard bearing *A*. The gears are fastened to the shaft on the headstock side of this bearing. Collars and washers are used to fasten the end of the boring shaft to the bearing plate *D* on the lathe carriage, and adjustments are made by means of a knurled nut *G*, three inches long. Two headless set-screws are used to keep the nut from working off the shaft. The nut can be set as tightly as desired, thus making a very steady shaft as regards the horizontal movement.

As a knurl was not available, the adjusting nut *G* was knurled by the following method: The compound rest was set horizontal with the work and the tool set as for chasing threads, setting the lathe to turn the coarsest thread possible. Proceeding as if only one thread were to be cut, the tool entered the work about 1/32 inch, but on the second cut, instead of going in the same line, the compound rest was moved ahead about 1/16 inch and a cut was taken. This process was continued until there were thread marks the full

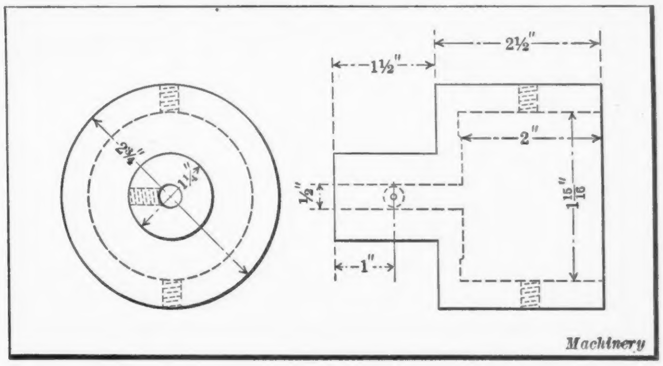



Fig. 2. Drilling Attachment for Use on Boring-bar shown in Fig. 1

length of the part to be knurled. Then the threads were reversed as if a left-hand thread were to be cut, and the same procedure followed. A very satisfactory knurl was produced by this method.

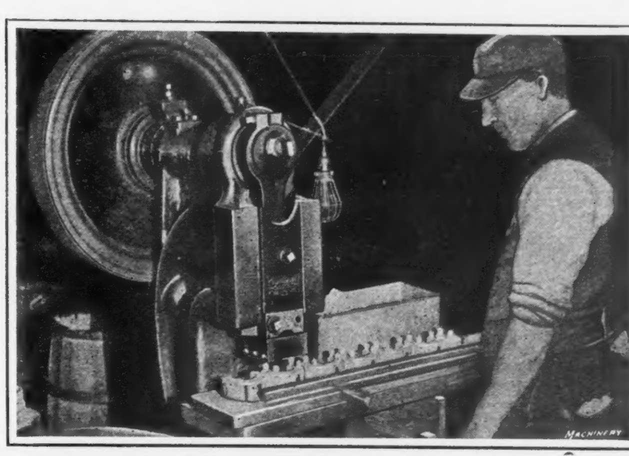
The cast-iron bearing plate *D* that goes across the lathe carriage, giving the boring-bar its horizontal movement, is fastened to the lathe with ½-inch bolts. The plate has lugs on the bottom that fit into the slots in the carriage. The hole in this bearing plate for the boring shaft is drilled and no bushings are required. The upper hole in the standard bearing *A* is drilled and not bushed, although no doubt a bushing would improve the wearing quality. The lower hole in this bearing and the hole in the bearing at the end of the bed are provided with bronze bushings. It is necessary to remove the tailstock when this boring attachment is used. When bolting the faceplate to the lathe, care must be taken to see that it is in line with the boring-bar. Once in place, there is slight possibility that it will have to be removed. The angle-plate braces are fastened so as to strengthen the faceplate; ½-inch cap-screws are sufficiently heavy to hold without vibration.

In Fig. 2 is illustrated an attachment for drilling work in the lathe. The attachment is made from a cold-rolled bar 2¾ inches in diameter and 4 inches long. While the one shown was made to receive a Morse ½-inch straight-shank, flattened-side twist drill, this attachment may easily be made to receive taper-shank drills.

Plant City, Fla. C. W. Wilkinson

## INSERTING WOODEN PLUGS WITH A PUNCH PRESS

One type of clutch-shifting yoke is a bronze casting with a cored pocket in which the oil is put. As no channels are provided for carrying the oil from this pocket to the friction sur-




Inserting Wooden Plugs in Clutch-shifting Yoke

face, four wooden plugs are pressed into the pocket. Capillary action then causes sufficient oil to exude from the plugs to lubricate the friction surface. The four plugs are pressed into the yoke at one stroke of a punch press.

As shown in the accompanying illustration, the punch press table has bolted to it a long, narrow plate casting with guides on the top. The shifting-yoke castings, with the wooden plugs just stuck in the holes, are slid along these guides. These plugs have a short tapered end so that they may be stuck in the holes by hand and fed along on the table. As the plugs are pressed into place, each yoke is pushed along by the next one to pass under the press head and soon drops off into a barrel at the end of the press. The plugs are pressed into place before the friction surface of the yoke is machined.

Flint, Mich. C. C. SPREEN

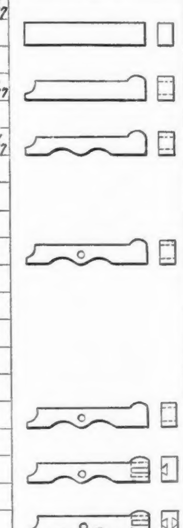
## USE OF SKETCHES ON OPERATION SHEETS

When a new article is to be manufactured in a large plant, an operation sheet, or what is sometimes called a general plan, which designates the various operations to be done from start to finish, is sent into the shops where the fixtures, gages, jigs, or tools are made. This operation sheet is valuable in showing what jigs, fixtures, tools, or gages are needed first. Thus each device follows in its regular sequence and a jig to be used on the seventieth operation will not be made before a jig used on the fifty-eighth operation. The equipment and manufacturing methods are clearly brought out before all concerned, and anything causing a fluctuation in the daily output can be easily localized and readily adjusted. The detrimental effects in the methods and costs adopted are easily discerned. In fact, operation sheets are summaries of each standard part of the product, and from them arrangements for the manufacture of other devices are often possible at a much smaller expense than would otherwise be the case.

However, the value of this sheet is increased by placing on it sketches of the article with each operation completed, as shown in the accompanying illustration. Then the jig or fixture maker sees immediately what his fixture or jig is desired to accomplish; oftentimes the man who makes the working drawings gets incorrect data or fails to put in every detail. Also, the foreman of the shop, by the aid of the sketches, can see more clearly what must be made to a nicety and what can be approximately correct and do the work just as well as if the piece or part were made to 0.001 inch, thus saving time and money. The writer knows of fixtures being made correct to 0.001 inch before they would pass inspection, but as soon as they were placed on a manufacturing job the operator would knock his piece out of its locating points in the fixture by means of a large babbitt hammer, and thus would throw off these points from 0.01 to 0.05 inch, yet the work would gage up, practically as well as when dead true. Of course, this would not do for all operations, but is permissible in some roughing cuts. The usefulness of the operation sheet is self-evident. It illustrates the article or part as it passes through the various channels of the works, so that the production overseers are acquainted with every detail in the manufacture of their product. In this case, the product has not passed the fourth operation, as it is waiting for the drill jig. It is, therefore, useless to complete the reaming jig for the fifth operation before this jig is made.

Operation Sheet ________ 10 Sheets No. 3 Article Locking Piece "Right" Model No. 4
Basis 2000 lb. Material 5/8" x 3/4" x 4" Steel Carbon 45 to 55 per cent Corrected to Dec. 24, '17 Estimated Labor Cost $5.00 per 100
Reference Henry Lee Specifications ________ Adjusting Cost ________
Economic Quantity to Order 20,000 Economic Rate of Production 40 per Hour

| Operation Number | Description of Operations | Est. Hours | Rate per 100 | Normal Hourly Output | Type of Machines Used | Quantity | Mach. Hours | Description of Fixtures | Description of Tools | Gages, Allowances and Tolerances | Required Date 3-16-18 Equipment | Required Date 5-17-18 Production | Sketch of Operations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cut up Stock | 500 | 0.75 | 40 | | | 8 | 1 Pair Jaws No. 320X | Mills | Snap Gage | O.K. | 50 2/14/17 | |
| 2 | Mill Top (4 at a time) | | | | Lincoln Miller | One | 8 | Fixture No. 2246 | Gang Mills | Profile Gage | O.K. | 50 2/16/17 | |
| 3 | Mill Bottom (4 at a time) | | | | Lincoln Miller No. 2 | One | 8 | Fixture No. 2247 | Gang Mills | Profile Gage | O.K. | 50 7/20/17 | |
| 3A | Inspect | 200 | 0.30 | 100 | | | | | | | | | |
| 4 | Drill one Hole | 400 | 0.60 | 50 | Drill Press Garvin No. 2 | One | 4 | 1 Drill Jig No. 7422 | No. 28 Twist Drill | Plug Gage, ± 0.002 inch | Held up for Jig | | |
| 5 | Ream one Hole | 267 | 0.40 | 75 | Drill Press Garvin No. 2 | One | 2 | 1 Reaming Jig No. 7423 | 1 Reamer 0.144 Diam. | Plug Gage, ± 0.002 inch | | | |
| 5A | Inspect | 200 | 0.30 | 100 | | | | | | | | | |
| 6 | Mill Ends for Length (4 at a time) | 334 | 0.50 | 60 | Lincoln Miller No. 2 | One | 8 | Fixture No. 2249 | Two Mills | Snap Gage "Go" Snap Gage "Not Go" | | | |
| 7 | Profile Vee Slot (Left Side) | 445 | 0.67 | 45 | 12 inch P. & W. Edging | One | 8 | Fixture No. 12,140 | Vee Mill | Vee Gage 12,410 Vee Gage 12,411 | | | |
| 8 | Profile Vee Slot (Right Side) | 445 | 0.67 | 45 | 12 inch P. & W. Edging | One | 8 | Fixture No. 12,140 | Vee Mill | Vee Gage 12,410 Vee Gage 12,410 | | | |
| 9 | Inspect | 200 | 0.30 | 100 | | | | | | | | | |
| 10 | Send to Assembling Shop | | | | | | | | | | | | |



Machinery

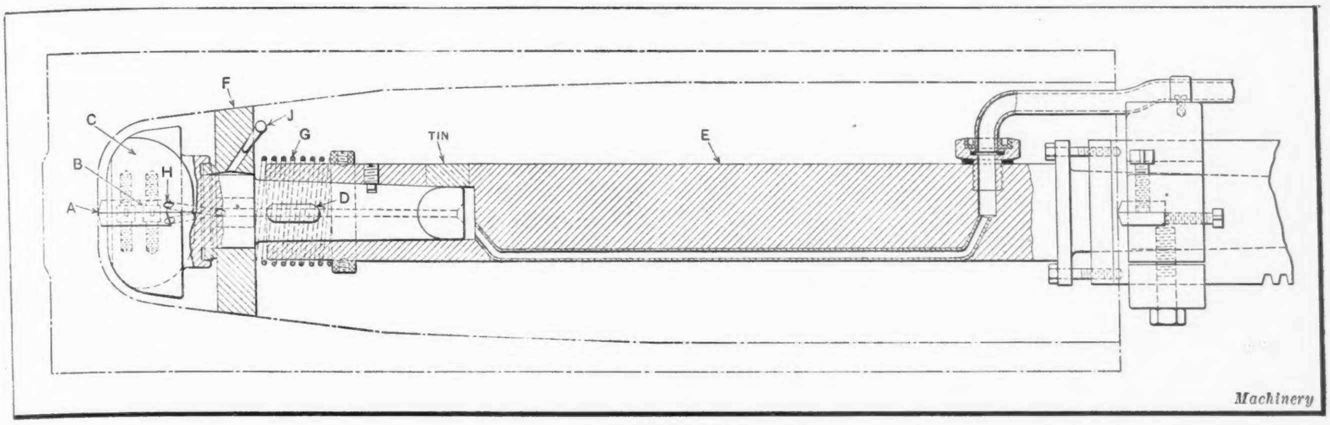
Operation Sheet showing Sketches of Different Operations

These sketches also help the manufacturer to decide what can be approximately correct and what must be exact. For instance, if a slight error is made in the manufacture of a jig or fixture, the foreman will know whether such an error is permissible. As these sketches show each successive operation, they assist greatly in demonstrating the locating points and giving such other data as is often thought unnecessary until the jig or fixture is being made.

New Haven, Conn. ERIC LEE

## SHELL FACING BAR

The writer designed the facing bar that is here illustrated for use on a horizontal boring machine built by the Niles-Bement-Pond Co. in facing the inside bottom end of forged shells 13 inches in diameter and 4 feet in length. The two blades *A* are secured by screws *B* to the removable holder *C*,




Bar with Two-blade Cutting Device

which is keyed at *D* to the bar *E*. This holder *C* is centered by star *F*, which, by the pressure of spring *G*, adheres to the inside of the shell rotating with it, having a running fit on the holder *C*. By this means the blade-holder is firmly supported and all chatter and vibration is eliminated during the operation. The easy disengagement of the chips is assured through the star, and sufficient lubricant is poured upon the blades through the holes *H*. The inside bearing of the star is oiled by a drilled hole, which is closed by the wooden plug *J*. The parts at the rear end of the facing bar are not special, being an ordinary attachment that is mounted directly on the spindle of the boring machine head.

Ruelle (Charente) France C. JOUVE

## PREVENTING LOSS OF TOOLS

It is an advantage to have the owner's name, not merely his initials, on all tools. When they are marked with the owner's name, if a tool is misplaced, the finder will recognize the surname and return the tool to Jones or whoever the owner may be. Employes are known in shops by their surnames, not by their initials. The writer feels certain that fully 75 per cent of all tools misplaced would be returned to the owner if the finder knew his name. Of course, one can always take a found tool to the tool crib, but it is more satisfying to return a tool directly to the owner, which eliminates the thought, and the possibility, that the owner may not receive the article from the crib. This is assuming, of course, that the finder desires to return the article found. But even were the finder otherwise inclined, it would yet be important to have all tools marked, as no man will use a tool with another's name on it, and tools thus marked are not easily sold.

The best method of marking the tools is to cut in the name with nitric acid. First the surface should be cleaned with benzine, turpentine or kerosene and then given a substantial coat of paint or varnish. When the paint is two-thirds dry, the name should be inscribed and the paint allowed to harden, preferably over night. The acid is applied with a camel's hair brush, which will not scratch and on which the acid will have little effect. Ten minutes after the acid begins to sparkle is sufficient time for a good impression.

New York City E. J. HIGGINS

## USE OF TECHNICAL TERMS

In reading technical journals, one notes considerable difference in the use of technical words, though it would seem to be one of the many duties of an editor to keep the various contributions within reasonable bounds. This supervision might be applied to advertising matter as well. Among those who misuse technical terms are the contributors of articles relating to machinery and tools for working sheet metals. When a company is formed for the manufacture of articles from sheet metal, it may be named the U. S. Stamping Co. and the machines it purchases for the production of stampings may be called punch presses. If a flat plate is used on the bed of a power press to help fill the opening, the piece may be called a bolster plate; but later the writer may use the word bolster when he means some part of his die. When the term sub-bolster is used, one naturally thinks of something under the bolster, but we learn that sub sometimes means over as well.

In the equipment necessary to produce an article cut and formed from a flat sheet, the manufacturer generally has a machine that he may call a press, a power press, a punch, a punch press, or a stamping press. When he wants to make or purchase the dies required to produce this particular article, how should he specify these tools when he writes to a tool shop for prices? Shall he send a drawing, or sample, of the article and ask for prices on a die to be used in a No. 20 X. Y. Z. press? If he does, can he be sure of getting quotations on all the necessary punches, dies, bolsters, strippers, extractors, etc., necessary for producing the article in the most approved manner?

Indianapolis, Ind. JOHN D. RIGGS

## RECESSING TOOL FOR GASOLINE ENGINE CYLINDERS

In automobile and marine gasoline engines having the head cast integral with the cylinder, the cylinder bore should be slightly larger beyond the upper limit of travel of the top piston ring. As the piston moves up and down, it gradually wears away the walls of the cylinder between its limits of motion, and if the upper end were not slightly enlarged, a ridge would soon be formed there. At the same time all the piston bearings are slowly worn away so that the travel of the piston is slightly increased; as a result, if a ridge were formed at the end of the cylinder, a knock would be produced.

The boring tool shown in Figs. 1 and 2 can be used to bore the enlarged part of cylinders cast so that they can be bored only from one end; this tool may be operated in either a horizontal or a vertical boring machine. The tool has some special features, principally the method of operating the cutter. The

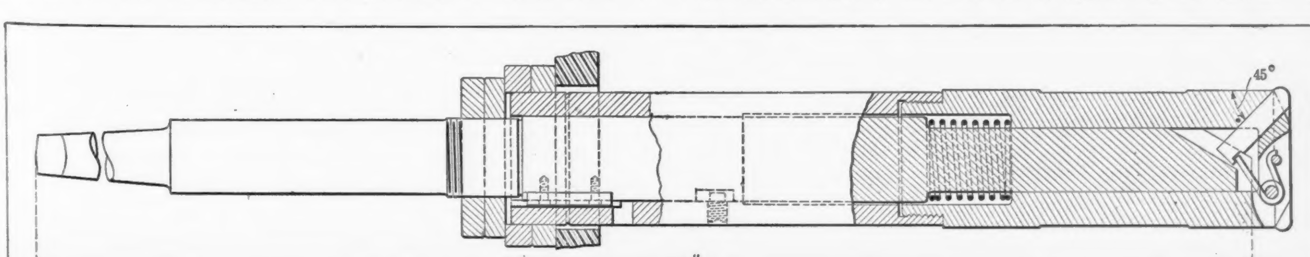



Fig. 1. Detail View of Tool for recessing End of Automobile Engine Cylinders

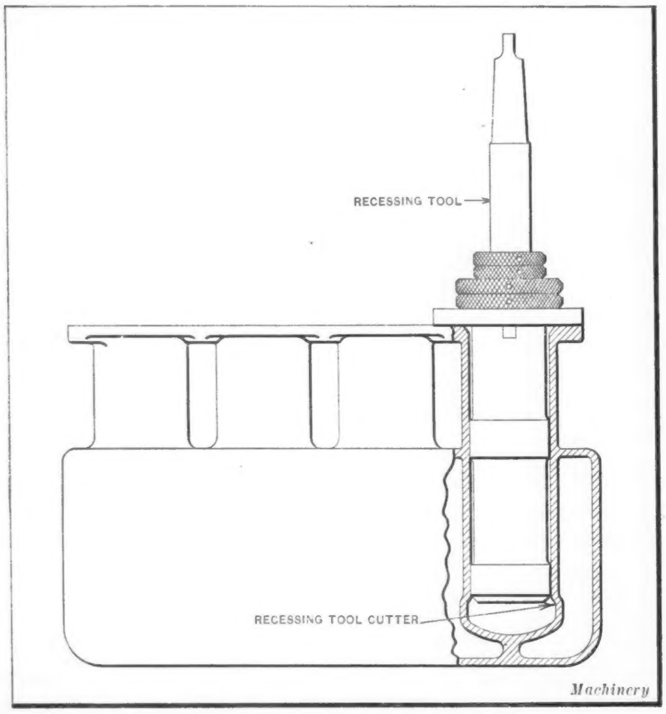


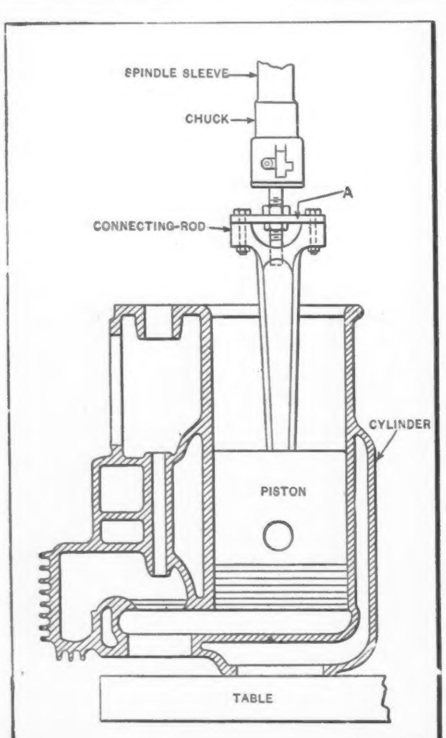

Fig. 2. Tool for recessing End of Automobile Engine Cylinders in Operation

outer sleeve is mounted on a plate, which is centered by pins placed in the cylinder flange bolt holes. The range of travel of the boring-bar is controlled by the stop-pin in the outer sleeve. A spring holds the boring-bar at the upper limit of its travel. At the lower end of the bar a slot is cut on an angle in which the cutter is located; this cutter is held in place by a spring, which also holds it against the back of the slot. Therefore, as the boring-bar is pressed down, the cutter is fed out and cuts the relief in the end of the cylinder bore.

Flint, Mich. C. C. Spreen

## LAPPING AUTOMOBILE CYLINDERS

In the accompanying illustration is shown a unique way of lapping a scored cylinder for an automobile engine. The cylinder block, which is for a four-cylinder engine, is laid out on the plate of a vertical, power-driven drilling machine, and the connecting-rod is clamped to the chuck, as shown, by means of a plate *A* laid across the face of the split crankshaft bearing. The cylinder wall and the piston are smeared with lapping compound or lapping powder before the piston is placed in the cylinder. Then by raising and lowering the spindle, while the piston is rotated in the drilling machine, the scored piston and cylinder are quickly lapped. It is well known that the lapping of cylinders by hand requires a good deal of time, and by doing it as described the job is finished in about one hour. Of course, it is understood that this method is used merely for repair jobs and not for the building of new engines.




Lapping Scored Automobile Cylinders

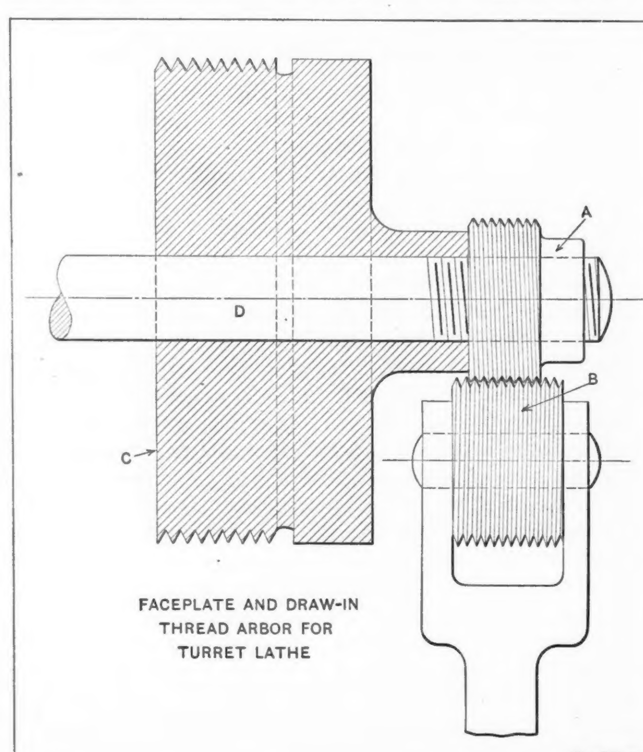
Art Sandberg
Ottawa, Ill.

## HARDENING CUTTERS FOR LARGE SHEAR

A shop that used a shear for cutting all kinds of stock up to two inches square had considerable difficulty keeping the cutters in good condition. The cutters, which were made of tool steel, 1¼ by 5 by 7 inches, and hardened in water, would bend or chip in a short time. As some cutters hardened in oil lasted six months, which was much longer than any previously used, but were somewhat too soft, it was decided to make the next set just a little harder by the following method: Eight inches of water and sixteen inches of oil were placed in the oil tank. When the cutters were heated to 1500 degrees F., they were plunged into this bath and moved continuously up and down, so that they were part of the time in water and part of the time in oil. These cutters, after six months' use, were still in good condition. R. M. P.

## SALVAGING HIGH-EXPLOSIVE FUSE ADAPTERS

When manufacturing high-explosive fuse adapters for shells for the Allies, quite a number came through too small to pass the gage. Rather than sacrifice the material involved and waste the time spent on them, as time was an important element in the contract, a means was sought to bring them up to size. A hardened steel roller *B* was therefore made of the proper size but with the threads cut deeper, so that when the adapter *A* and the roller *B* were brought together and revolved under pressure, the metal was forced into the deeper threads of the hardened roller and brought to the required size. To operate, the adapter *A* is screwed on the threaded draw-in arbor *D*, which is then drawn back against the faceplate *C*, and the thread roll *B* is brought against the adapter *A* by means of the cross-slide.




Method of bringing Fuse Adapters to Size

Boston, Mass. John A. Shand

## USE OF AIR-OPERATED HAMMERS

A development that deserves attention in the design of machine and industrial plants is the use of compressed air for operating press hammers ordinarily employing steam as the motive power. Frequently, comparatively small plants are operated by motors driven from current purchased from outside public utility companies or gas-producer plants. In such instances the use of steam for operating the hammers necessitates the installation of a high-pressure boiler unit with its

fixtures, piping and attendance. On the other hand, practically every manufacturing plant is equipped with a motor-driven air-compressing outfit for use in the various tools. In motor-operated plants the use of air will eliminate the necessity for providing high-pressure steam boilers, piping, etc.

While the cost of operating the hammers by air will probably be higher than the cost when using steam, it is a question whether this added cost will not be more than offset by the savings realized from reduced investment, reduced cost for attendance, simplification, and savings in floor space. Besides, the air-operated hammer will strike a quicker and harder blow; there is also no large quantity of condensation or drips to be taken care of, and the heat surrounding the hammer is reduced, improving the working conditions.

The use of compressed air necessitates the installation of a large air receiver on the intake line, in order to insure a plentiful supply of air ready for the demands of the hammer. This receiver will also reduce the size of the air-compressing equipment needed. With the use of air for operating hammers, it is important to watch carefully for leaks in the pipe lines and connections, which are bound to occur because of vibration and which are not as noticeable as steam leaks.

Philadelphia, Pa. W. A. Lailer

## SCREW MACHINE SET-UP CHARTS

Some time ago, while working in the hand screw machine department, doing piece-work on pneumatic drill and hammer

| CAT. NO. | OP. NO. | NAME OF ARTICLE | SIZE AND NAME OF MACHINE | | |
|---|---|---|---|---|---|
| P.D.E. 54 | 1 | Stuffing-box nut | 2" | Pratt & Whitney | Screw Mach |

DRIVE

| GEARS | | BELT | X |
|---|---|---|---|
| SPEED | CONE NO. | 1 | 2 | 3 X |

TABLE FEED

| FIRST | SECOND | THIRD | FOURTH |
|---|---|---|---|
| | X | | |

CROSS-SLIDE

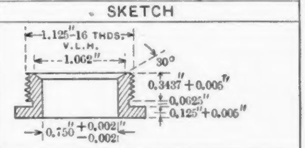
| BACK | FRONT |
|---|---|
| Recessing tool | Cut-off tool |

CROSS-SLIDE FEEDS

| FIRST | SECOND | THIRD | FOURTH |
|---|---|---|---|
| — | — | — | — |

PCS. PER HOUR 15

SKETCH




REMARKS

Use 1¼" C.D. Steel.
Nut must fit ring gage snug and must screw down to shoulder.
Do not let machine stand idle while trying nut in gage; let reamer run in on second feed.

| | |
|---|---|
| 1 | Ball bearing stop, set 1" from face of collet. |
| 2 | Turn for thread to 1.120 dia. |
| 3 | Drill hole to 0.734 dia. Note:– Cut recess while drilling hole on 2nd feed. |
| 4 | Ream hole to size and cut 30° chamfer with combination reamer. |
| 5 | Break corner for thread with overhanging tool. |
| 6 | Cut thread with Geometric die in 2 cuts shift to slow speed on countershaft. |
| 7 | Cut off to length. |
| 3 | |

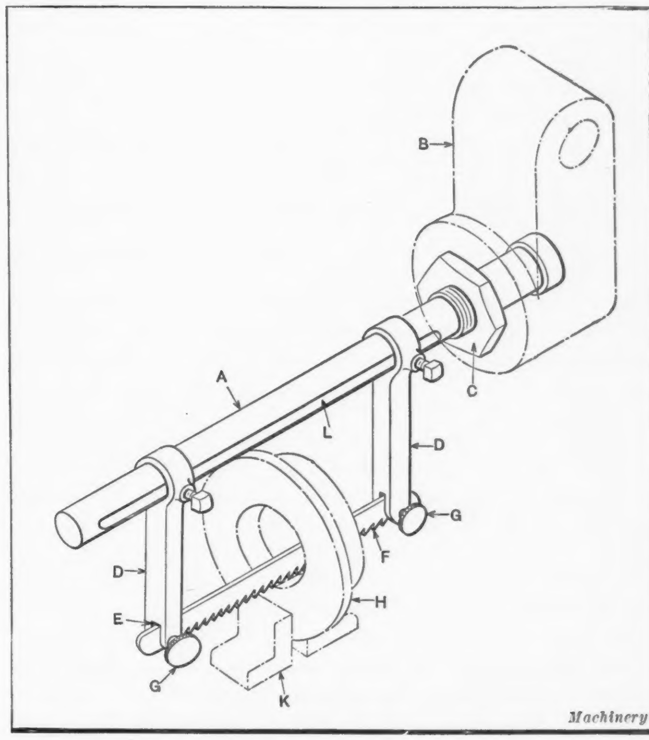
*Machinery*

**Screw Machine Set-up Chart**

parts, the writer had a job on which he made from sixty to seventy-five cents an hour; but about four months later, on the same job, all he could make was forty-five cents an hour and he could not discover the reason until he was nearly through with the job. He had forgotten that he formed the piece at the same time that he drilled the hole.

About a month later the writer was appointed assistant foreman. As he had a little trouble remembering the different set-ups, he ruled up a card, like the one here shown, had a thousand printed, and then worked overtime a few evenings filling them out. Although nearly all the hands were green, with these cards they quickly learned how to set up their jobs, because the cards were fool-proof. As a result, the writer was placed in the piece-rate and lay-out department.

Aurora, Ill. J. J. Borkenhagen




**Attachment for cutting Keyways on the Shaper**

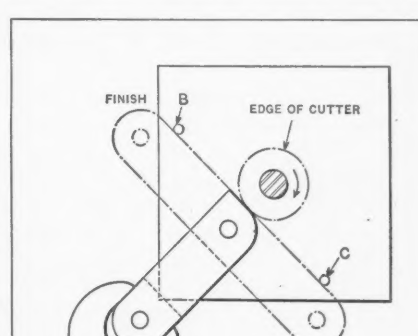
## CUTTING KEYWAYS ON THE SHAPER

With the attachment shown in the accompanying illustration satisfactory keyways may be quickly cut on the shaper; the attachment is especially good for keyways in small holes. The bar $A$ is held in the regular shaper swivel $B$, being clamped in position by the nut $C$. This bar supports two rods $D$ at the lower end of which are slots $E$ for the keyseating tool $F$, which is held in place by knurled screws $G$. The work $H$ is held in the jaws $K$ of the shaper. The attachment shown has a flat $L$ on the bar $A$ to keep the link sliding in line when adjusted, but a key and keyway are preferable to the flat. When the work is to be removed, the knurled screws $G$ are loosened and the tool removed. Often larger keyways can be made with a smaller cutter, but in general the cutter should be made for the size of keyway required.

Irvington, N. J. Charles Eisler

## MILLING ON A DRILL PRESS

Some time ago the writer had several hundred machine steel yoke or clevis ends of different sizes to be faced off round with a fairly good finish and shape. As shaping, grinding, and filing was not very satisfactory, the device illustrated was designed and used with good results. An old box jig was bolted to a drill press table, and a hole was bored to fit a short milling machine arbor. A spiral milling cutter with an outside diameter that would finish the yoke to the desired size was mounted on this arbor. The piece to be machined was placed on stud $A$ in the position indicated by the dot




**Device for milling Yoke Ends**

and dash lines, and moved through an arc of 180 degrees by using an open-end wrench. Stop-pins *B* and *C* prevented the piece from being machined too far. The bulk of the material to be removed was first cut out on a shear or by drilling a number of small holes.

Harvey, Ill. H. S. ZEVENHOUSE

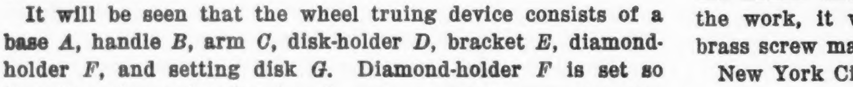
## GRINDING WHEEL TRUING DEVICE

During the past three years of unusual industrial activity there has been an exceptional demand for many types of gages. It is a matter of fact that gage-making at the present time has been brought much closer to a strictly manufacturing basis than was formerly the case; but before this high degree of efficiency was reached manufacturers had to feel their way by slow and expensive steps. There are still some concerns that are producing component gage parts by hand, and where this method is followed the cost of gages is prohibitive in many cases. Consequently, any method or means of increasing the rate of production and accuracy with which gage-making can be done is of great service both to toolmakers who take contracts to supply gages to manufacturing plants, and the plants in which such gages are to be used.

The shop in which the writer is employed has been actively engaged in designing and manufacturing gages for the parts of a military rifle. From time to time my assistant and I have introduced time-saving methods for the rapid production of gage parts, the methods being such that they can be depended upon to produce work of the required accuracy. Although we make no claims concerning the originality of this method, we are fully convinced that the results obtained with it are entirely satisfactory, and so far as we know the method itself is new. The accompanying illustration shows a truing device made to dress grinding wheels to an exact radius of curvature. Gage-makers who make templets to a certain radius of curvature and then proceed cautiously to true a wheel up to fit such a templet will appreciate the value of the present method.

It will be seen that the wheel truing device consists of a base *A*, handle *B*, arm *C*, disk-holder *D*, bracket *E*, diamond-holder *F*, and setting disk *G*. Diamond-holder *F* is set so that the diamond point is off center, and in operation the diamond is swung in a circular arc over the wheel by turning handle *B* so that "radius arm" *C* is swung about its pivot in block *A*. Diamond-holder *F* is made round so that a sharp facet of the diamond may be centrally located by turning this holder in the bracket. The capacity of this truing device is for truing grinding wheels to radii from 0.010 to 1 inch.

Base *A* is ground on all surfaces, and it will be apparent that a set of hardened and ground disks *G* must be furnished with the attachment to provide for setting the diamond point for truing wheels to the desired radii. In setting the attachment for truing a convex surface on the wheel, disk *G* is



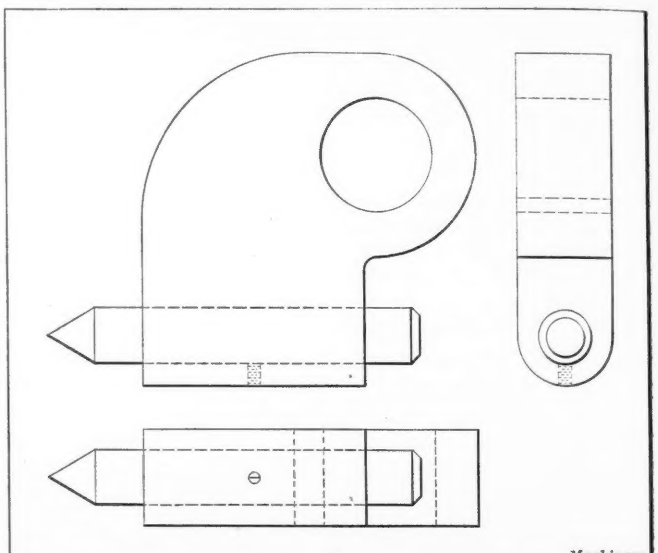

Device for truing up Grinding Wheel to a Convex Surface

placed on arbor *D* and the diamond point is brought up into contact with the disk. This locates the diamond in the desired position for truing a convex surface on a grinding wheel to a radius of curvature corresponding to the disk used in making the setting. The throat of the radius arm is of sufficient depth to accommodate grinding wheels up to 7 inches in diameter, and no difficulty is experienced in finishing the curved grinding face to an accuracy of 0.0001 inch on the radius. The holes drilled in the base of the attachment are merely to lighten it.

Springfield, Mass. F. C. BOLTON

## LAYING-OUT FIXTURE FOR MILLING MACHINE

The practice of spacing holes in work from center-punch marks is so general that the fixture here shown may be used to excellent advantage. It is clamped on the milling arbor and the centers are accurately spaced on the work by the use of




Laying-out Fixture for Milling Machine

the index dial on the feed-screw. The center-punch should fit the holder snugly, so that when the punch is raised from the work, it will not fall down again. However, a small brass screw may be used to take up any slight wear.

New York City E. J. HIGGINS

## AMMONIA FOR FIRE EXTINGUISHING

The writer's attention has been called to an article in the January number of MACHINERY bearing the title "Ammonia for Fire Extinguishing," which advocates the use of ammonia instead of water for fire protection. It says that, as combustion depends on free oxygen, the displacement of that constituent of the air by ammonia gas will have the effect of "suffocating" combustion, so that a little ammonia gas will go a long way toward extinguishing a good sized fire. Means by which this medium might be manually or automatically liberated in a building in case of fire are also given. It is pointed out that, since ammonia is a gas and will rise in air, it should be liberated near the floor. Had the use of carbon dioxide, which is heavier than air and accordingly could be introduced through overhead piping similar to the present sprinkler pipes, been advocated, the idea might have been more feasible, especially as that gas would be more active than ammonia in putting out flame and less active in extinguishing human life.

There is little fear that an experiment of this kind would be tried a second time by the same person if the matter were brought to the attention of the proper authorities, especially at the present time, when, on account of ammonia shortage due to the urgent demand for that substance for the manufacture of explosives, food-conserving industries employing ammonia as a refrigerant are facing possible restrictions.

New York City F. E. MATTHEWS
Vice-president of American Society of Refrigerating Engineers.

# NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

IN THIS NUMBER



## NEEDHAM DOUBLE-PURPOSE LATHE

THERE are a large number of machine shops in small towns, which handle an occasional job calling for a lathe swinging up to about 40 inches, but such a large machine would not be well adapted for machining the average run of work handled in these shops. To meet the requirements of such machine shops, A. W. Needham, 72-74 Tenth St., Long Island City, N. Y., has developed the double-purpose lathe illustrated and described herewith. The best idea of the provision made for adjusting the swing of this lathe will be gathered by reference to the end views shown in Figs. 3 and 4, where it will be seen that cross-slides are provided to support the headstock and tailstock, and that the two back V-ways on the bed of the machine are placed at a considerably lower level than the front way, so that when the headstock and tailstock are pushed back, this lower position of the back ways helps to increase the swing.

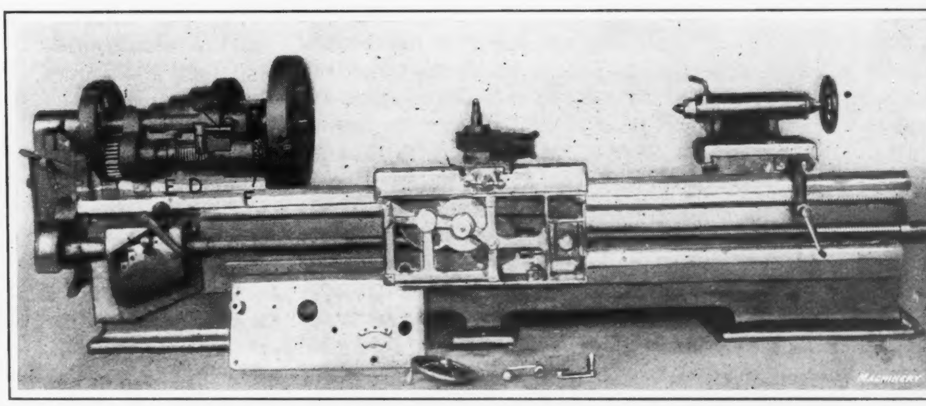


Fig. 1. Needham Double-purpose Lathe with Front Plate removed from Apron

In order to adjust the transverse position of the headstock, it is merely necessary to loosen four bolts and then push the headstock to the desired position on its cross-slide. After this setting has been obtained, the four bolts are retightened to clamp the headstock in the desired position. Adjustment of the tailstock is secured in exactly the same way. With the headstock and tailstock in the back position, the lathe has a swing of 40 inches, and it is of sufficiently heavy construction so that it may be used for turning car wheels and other heavy work. With the headstock in the forward position, a small faceplate is furnished, which is shown leaning against the lathe bed in the rear view of the machine shown in Fig. 2, and equipped in this way the lathe is adapted for handling the average run of heavy work that comes to a jobbing shop.

Forty-two changes of feed are available on this lathe. In the front view of the machine it will be seen that at the left-hand end of the feed-screw there is the usual arrangement of quick-change gears, which provide seven changes of feed. Now, referring to the end view of the lathe shown in Fig. 3, it will be seen that lever *A* is furnished with a locating pin which may be pushed into any one of three holes. This lever actuates sliding gears in this case, which provide for multiplying the seven feed changes of the quick-change gear at the front of the machine, giving a total of twenty-one changes of feed. By means of two change-gears in case *B* the number of available feed changes is again multiplied, giving a total of forty-

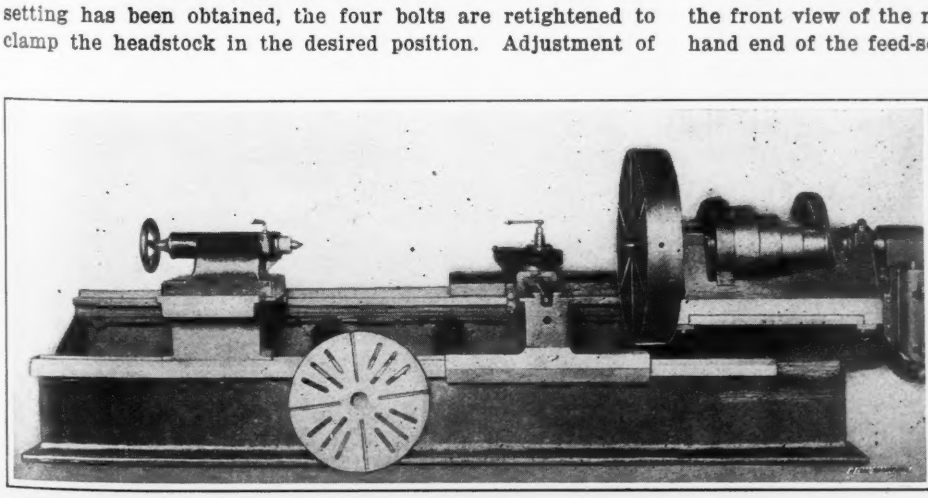


Fig. 2. Opposite Side of Needham Double-purpose Lathe shown in Fig. 1

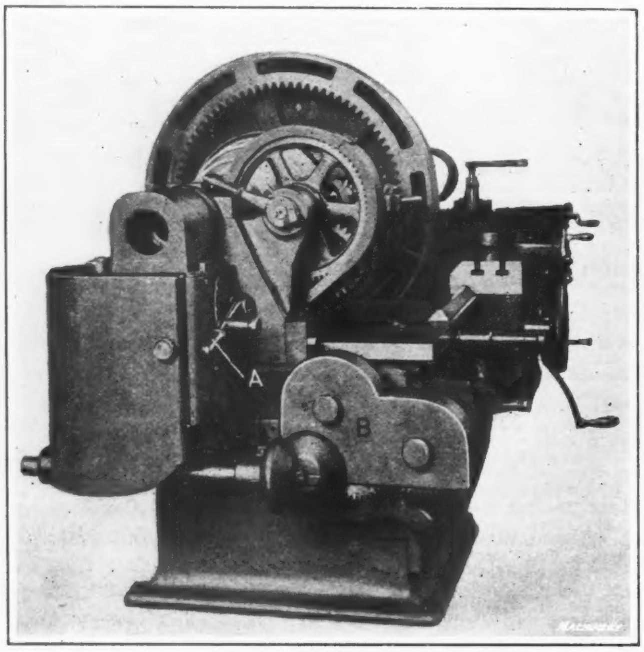


Fig. 3. End View of Lathe showing Arrangement for obtaining Feed Changes

two rates of feed. It will be apparent by referring to the illustrations that the headstock of this lathe is furnished with a four-step cone pulley and single back-gears. For handling average classes of work, the drive may be either direct or through the back-gears, which are designed in accordance with the usual practice except that they are placed at the front of the lathe spindle. For heavy-duty work where the large faceplate is used, it is naturally desirable to drive by means of the faceplate gear, which furnishes additional power. To provide for obtaining this result, a lever *C*, Fig. 1, is furnished at the front of the lathe, which is mounted at the top of a short vertical shaft which carries a pinion *D* at its lower end. It will be apparent that this pinion meshes with rack teeth cut in a horizontal sliding shaft *E* that carries a pinion *F* at its right-hand end. When it is desired to drive through the faceplate gear, lever *C* is turned to slide horizontal shaft *E* to the right and bring pinion *F* into mesh with the faceplate gear. This movement of shaft *E* results in disengaging a clutch so that the back-gears are thrown out at the same time that the faceplate gear is engaged.

Attention is called to the fact that in the front view of the lathe shown in Fig. 1, the apron has the front plate removed and shown leaning against the lathe bed. This front plate is so designed that by removing four cap-screws and knocking out the taper pins that hold the handwheels on their shafts, the front plate of the apron can be removed to give access to the mechanism. It will also be noticed that despite this provision for removing the front of the apron, each stud in the apron is furnished with a double bearing support. By removing the spider, all gears may be removed in four minutes without disturbing the apron, as the gears are all in front of the apron. The lead-screw can also be removed without disturbing the carriage or apron. Attention is called to the manner in which bearings are provided for in the apron at the front of the lathe bed. The apron is gibbed to the bed in such a way that the carriage bridge may be removed—the bridge being made separate from the carriage for this purpose—and a special brace substituted in its place, so that the lathe swings 40 inches over both the carriage and ways. When this is done, the apron will be quite firmly supported on the bed and capable of operating satisfactorily.

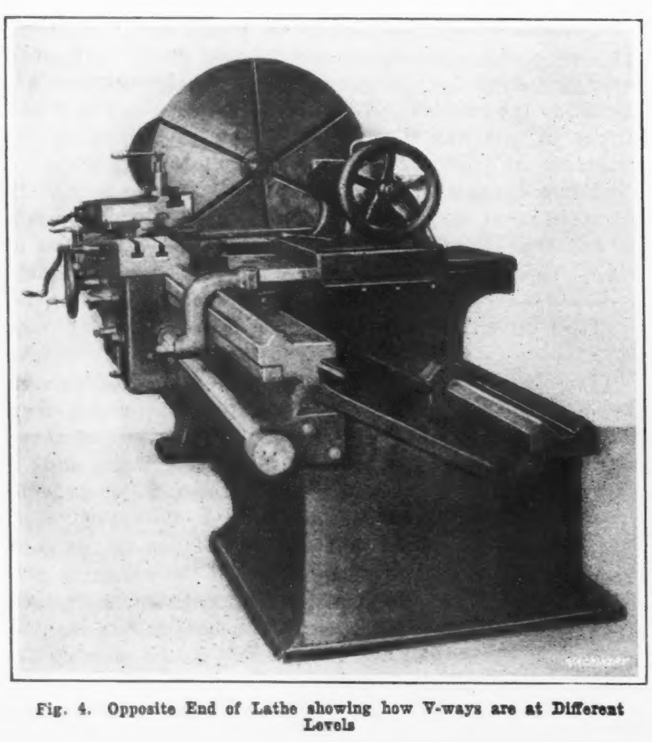
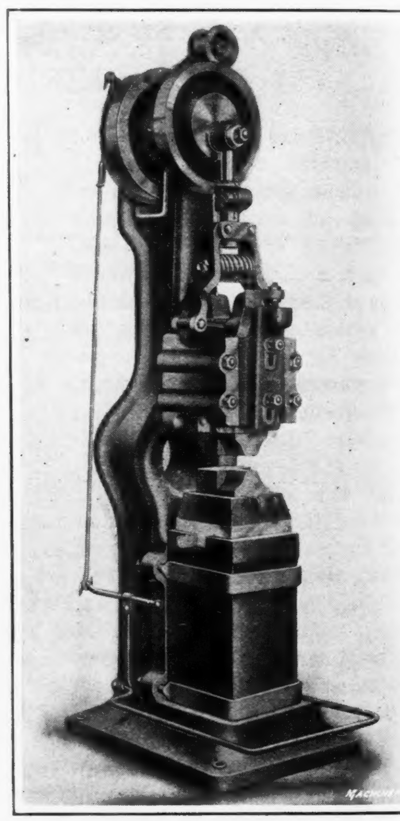


Fig. 4. Opposite End of Lathe showing how V-ways are at Different Levels

## FAIRBANKS POWER HAMMER WITH ADJUSTABLE GIB

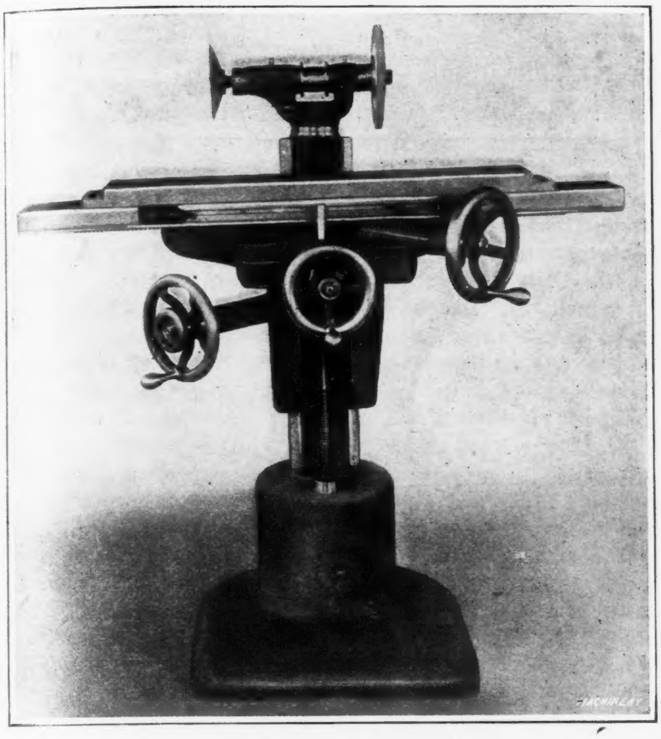
The United Hammer Co., Oliver Bldg., Boston, Mass., are now building the Fairbanks power hammers with an adjustable bronze taper gib the object of which is to provide for taking up wear in the ram guides. With this gib, which may be seen in the accompanying illustration, provision is made for rapidly and accurately making the necessary adjustment. The advantage of such an arrangement on a Fairbanks hammer is that it makes it possible to obtain much finer adjustment of the ram than was formerly the case. It should also be mentioned that these gibs and faceplates have been so designed that they may be fitted to hammers which were originally built without this improved feature.



"Fairbanks" Power Hammer made by United Hammer Co.

## MANHATTAN UNIVERSAL TOOL GRINDER

In the accompanying illustration there is shown a universal tool grinding machine which is a recent product of the Manhattan Machine & Tool Works, 42-50 Market Ave. N. W., Grand Rapids, Mich. It will be apparent from the illustration that this machine is of comparatively simple design, without complicated mechanism that is likely to wear or get out of order. It is furnished with a table, 6 by 42 inches in size, which has a working surface of 6 by 22 inches. This table has a maximum longitudinal movement of 22 inches, a transverse movement of 8 inches, and a vertical movement of 12 inches. The greatest height from the center of the grinding wheel to the surface of the table is 12 inches, and work up to 9 inches in diameter by 21 inches in length can be supported on centers. The following equipment is furnished for use in connection with this tool grinding machine: one internal grinding attachment, one pair of central head- and tail-centers, one pair

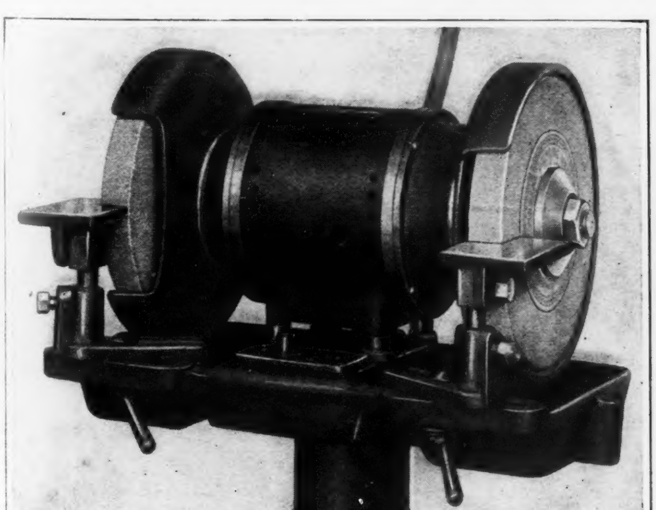


Universal Tool Grinder built by the Manhattan Machine & Tool Works

of offset head- and tail-centers, one faceplate 8 inches in diameter, one chuck for the central head, one swivel base vise, six pairs of grinding wheel flanges, six driving dogs of assorted sizes, one height gage, one tooth-rest socket, seven extension bars, three spring tooth-rest springs, six T-slot bolts, and a countershaft for driving the machine.

## UNIVERSAL ELECTRIC GRINDING MACHINE

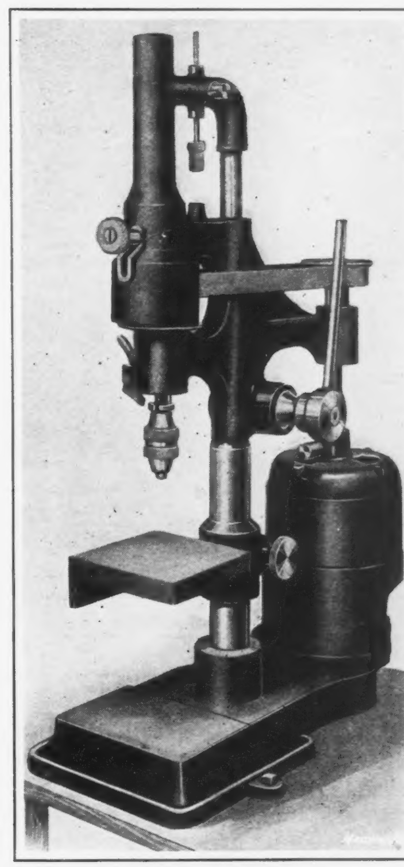
One of the recent products of the Universal Electric Co., 9 Oliver St., Newark, N. J., is a grinding machine built in bench and floor types. This machine has the spindle mounted in SKF ball bearings and is provided with grinding wheels 8 inches in dameter by 1 inch face width. Adjustable guards are provided over the grinding wheels, these guards being held by friction furnished by spring washers, which makes it possible to turn the guards to any desired position without the necessity of loosening screws. The tool-rests are adjustable in all directions and the electric motor is mounted on a baseplate that has a depression under each wheel to form a reservoir for cooling water. A two-pole push-button knife switch controls the motor and this switch is conveniently located for the operator. Motors may be furnished for operation on direct-current circuits or for two- or three-phase alternating-current circuits.



Grinding Machine built in Floor and Bench Types by the Universal Electric Co.

## HIGH-SPEED BALL BEARING DRILLING MACHINE

The motor-driven sensitive drilling machine shown in the illustration which accompanies this description is a recent product of the High Speed Hammer Co., Inc., 307 St. Paul St., Rochester, N. Y. This is known as a Model E50 ball bearing machine. It weighs only 60 pounds so that it may be readily moved about the shop and the drive is by a motor especially designed for connection to electric lighting circuits where the potential is from 110 or 155 volts, either alternating or direct current. Special attention is called to the spindle lock which facilitates changing drills, it being possible to release or engage a drill with one hand, and the operator is not required to hold the pulley with the other hand. Annular ball bearings are used throughout this machine and there is also an end-thrust bearing which takes the pressure of the spindle and practically eliminates friction. An adjustable depth gage is furnished which enables stop drilling operations to be performed with a great degree of accuracy.



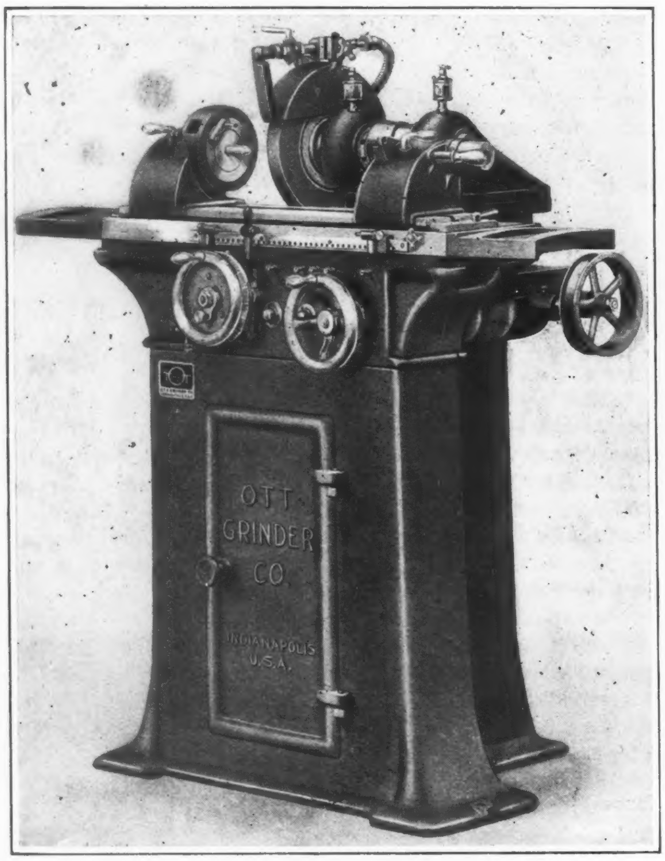
Ball Bearing Sensitive Drilling Machine built by the High Speed Hammer Co.

This machine is adapted for driving drills ranging from the smallest sizes up to 3/16 inch in diameter. The standard spindle speeds are 2100 and 6000 revolutions per minute, but the machine can be furnished with special pulleys to provide for driving the spindle at any speed up to 10,000 revolutions per minute. The spindle is made of heat-treated steel; it is ground to size and guided through a bronze quill, with the spindle supported at each end in an annular ball bearing. A quick-adjustable table provided on the machine has a working surface 5½ by 5 inches in size, and work up to 4⅜ inches high can be drilled. The surface of the table is ground to provide for accurately drilling holes in relation to finished surfaces on the work. The base of the machine is furnished with a ground working surface 4 by 6 inches high, and work up to 7½ inches high can be drilled in place on this base. Surrounding this base there is an oil-groove. An idler pulley takes up any stretch in the belt, which is of the endless woven type. It will be seen that the front pulley and upper part of the spindle are covered by a semi-tubular guard which insures safety of the operator. Either hand or foot control may be provided. The principal dimensions of the machine are as follows: over-all height, 24 inches; size of base, 7½ by 18 inches; capacity of driven motor, 1/10 horsepower; diameter of spindle, 7/16 inch; maximum spindle feed, 2¼ inches; available spindle speeds, 2100 and 6000 revolutions per minute; and capacity, for drilling to center of 6-inch circle.

## OTT PLAIN GRINDING MACHINE

The 5- by 18-inch plain grinding machine which forms the subject of the following description is a recent product of the

Ott Grinder Co., Indianapolis, Ind. This machine is equipped with a grinding wheel 10 inches in diameter by 1¼ inch face width, that is carried by a wheel-stand which moves transversely on large vee and flat ways, movement of the wheel-stand being controlled by a handwheel. The wheel-spindle is made of special steel which is hardened, ground and lapped, and the bearings are bushed with bronze and furnished with means of compensating for wear. Alignment of the headstock and tailstock is secured from the front edge of the swivel table. The automatic cross-feed mechanism is of simple de-




Five- by Eighteen-inch Plain Cylindrical Grinding Machine built by the Ott Grinder Co.

sign and provision is made for varying the rate of feed while the machine is in operation. Both the countershaft bearings and the loose pulleys are equipped with Hyatt roller bearings.

This machine is especially adapted for production grinding where large quantities of duplicate straight or tapered cylindrical parts have to be finished within close limits. It is claimed that the machine will handle work that is now being ground on larger machines, thus economizing in floor space and increasing the facility with which grinding operations can be performed. The automatic cross-feed operates at each reversal of the table and may be adjusted to its feed limits while in operation. When the work is ground to size the feed is automatically thrown out and a positive stop is provided for the hand-feed. Drive to the table is transmitted through a worm and worm-wheel, insuring smooth, uniform travel, which is controlled by adjustable dogs that may be quickly set in the desired positions. The table handwheel is disconnected when the power traverse is employed, and the reversing mechanism is non-centering, thus assuring accurate and positive reversal.

To provide for performing taper-turning operations, the table swivels on a large central stud which is hardened and ground to size. Clamps secure the table at both ends, and the right-hand clamp is graduated for setting the table to grind


Oil-hole Drill made by Arthur Colton Co.

tapers expressed in inches per foot. The headstock is arranged for dead-center drive, and is clamped to the swivel table by means of a T-head bolt; and the tailstock spindle is operated by a spring lever so that it can be rigidly clamped if desired; the tailstock is secured to and maintains its alignment on the swivel table in the same way as the headstock. A pump is furnished which has ample capacity to supply a copious flow of water for wet grinding operations. The equipment furnished with the machine includes one 10- by 1¼-inch grinding wheel, one universal back-rest, one wheel-truing device on the tailstock, one center-grinding attachment, one pair of adjustable work-dogs, a set of overhead works, and the necessary water guards and wrenches.

The principal dimensions of the machine are as follows: swing, 5 inches; capacity between centers, 18 inches; range for taper grinding, up to 3 inches per foot; diameter of headstock and tailstock spindles, 1½ inch; taper of work-centers, No. 6 Jarno; dimensions of front grinding wheel-spindle bearing, 1⅝ by 3¾ inches; dimensions of rear spindle bearing, 1½ by 3¾ inches, minimum rate of automatic cross-feed, 0.00025 inch; maximum automatic cross-feed, 0.005 inch; range of table feeds per minute, 20 to 65 inches; horsepower required to drive machine, five; floor space occupied, 31 by 68 inches; and net weight of machine, approximately 1700 pounds.

## COLTON HIGH-SPEED OIL-HOLE DRILLS

The Arthur Colton Co., of Detroit, Mich., are now manufacturing a line of oil-hole drills, a phantom view of one of which is shown in the accompanying illustration. These are forged and twisted drills, the twisting operation being performed after the oil-holes have been drilled. Colton oil-hole drills are made in all standard sizes from high-speed steel.

## GISHOLT SHELL BORING LATHE

In Figs. 1 and 2 there are shown two views of a special 25-inch boring lathe which has recently been developed by the Gisholt Machine Co., of Madison, Wis., for boring 6-inch shells; and Fig. 3 shows cross-sectional views of 155-millimeter shrapnel and high-explosive shells in which *A*, *B*, *C* and *D* indicate the finished surfaces which can be machined on this lathe. For performing these operations use can be made of either a

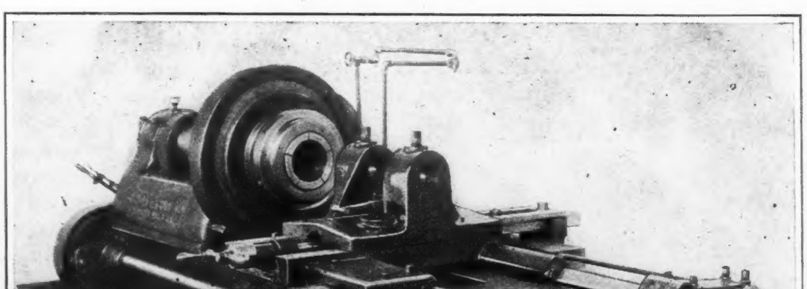


Fig. 1. Twenty-five-inch Shell Boring Lathe built by the Gisholt Machine Co. for boring 6-inch Shells

single-point cutter in the boring-bar, with a former block on the taper attachment which is shown at the back of the machine in Fig. 2, or with a boring head located on the boring-bar and with the cross-slide carriage set in a central position. In addition to its application for the performance of boring operations in shells, this lathe could be used to advantage for boring many other clásses of work.

These 25-inch Gisholt lathes are made in several models,

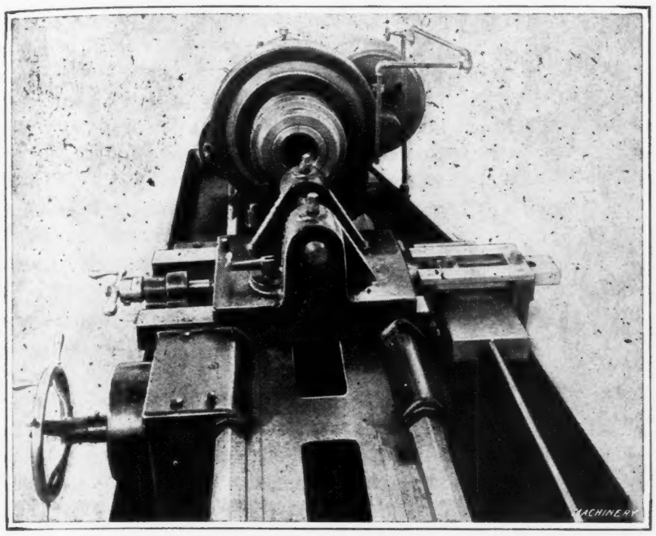



Fig. 2. Partial View of Lathe showing Arrangement of Taper Turning Attachment

some of which are furnished with turrets and others with simple toolposts, etc., according to the particular operations for which individual machines are to be used. Also the lathes may be equipped with either a collet chuck or with a 24-inch three-jaw universal geared scroll chuck, or with a four-jaw independent chuck. This machine is one of the special type of lathes built for shell work in munition plants in England,

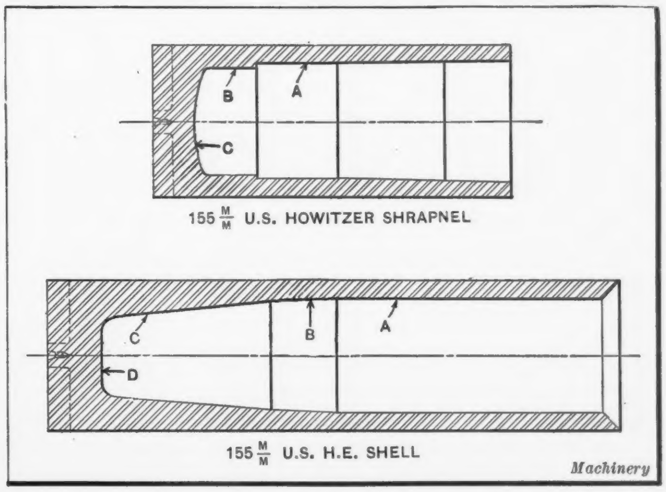
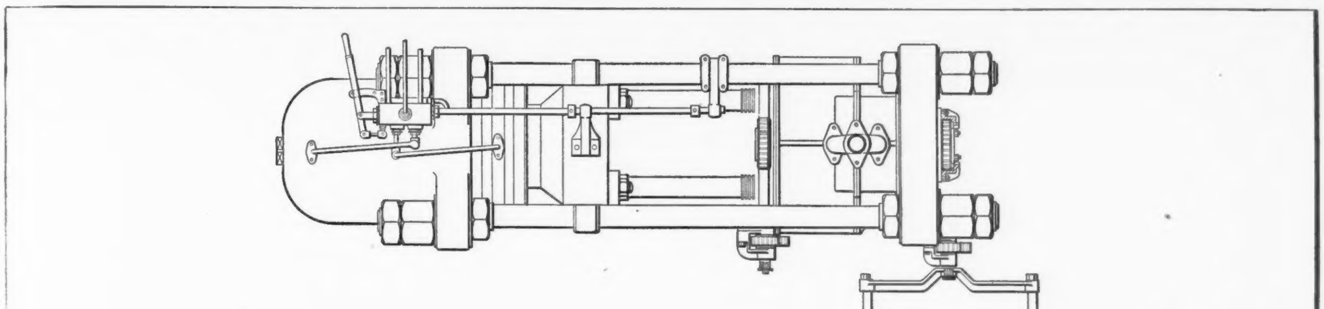



Fig. 3. Cross-sectional Views of 155-millimeter Shrapnel and High-explosive Shells showing Surfaces to be machined

France, and Italy. Until recently, the demand for the machines from abroad has been so great that no attempt was made to bring them to the attention of the munition manufacturers in this country. At present, however, several lots of this type of lathe are being built for use in American plants.

## SOUTHWARK LEAD CABLE COVERING PRESS

The Southwark Foundry & Machine Co., of Philadelphia, Pa., are now building a hydraulic press for applying a lead covering to cables. This press is built in accordance with designs worked out by R. Poliakoff. The cable to be covered with lead is fed into the press through the roller guides of the curved canal *A*, the radius of which is sufficiently large to prevent danger of impairing the pliability of the cable when passing through or distorting it. The cable next passes through bushing *B* and comes into contact with the molten lead, which fills




Hydraulic Press built by Southwark Foundry & Machine Co. for applying Lead Covering to Cables

the ring space between this bushing and die *C* through which the cable is drawn after being covered with lead. As a result of being drawn through the die, the surface of the lead is smoothed out and the diameter of the lead coating is reduced to exactly the required size. The end of the cable comes out of the press leaded and completely finished, so that it can be wound on a drum which serves the additional purpose of furnishing the means for drawing the cable through the machine.

The main parts of the mechanism of this hydraulic cable-covering press may be briefly described as follows: The section of the press required for applying the lead coating is composed of two cylindrical chambers *D* which are filled with molten lead, two bushings *B* and *E*, and the die *C*. The hydraulic part of the press is intended to keep the molten lead in chambers *D* under a definite pressure. Lead is melted in a pot located above the press and delivered into chambers *D* through a pipe *F*. In order to insure a uniform delivery of lead into chambers *D*, pipe *F* is connected to them by an elbow *G*. From these chambers the molten lead comes into contact with the cable through a ring-shaped space between bushing *B* and die *C*; and by moving bushing *B* backward or forward, it is possible to adjust the size of the ring opening to regulate the amount of cable surface that is in contact with the molten lead at any time.

The lead contained in chambers *D* is always under pressure applied by rods *H*, which act as pistons in chambers *D*. These rods are actuated by pressure from hydraulic cylinder *I*, and as the supply of lead in chambers *D* is reduced, rods *H* move to the right to maintain a uniform pressure. When the rods reach the extreme of their movement toward the right, drawing of the cable is stopped and rods *H* are moved back to their original position by shifting the operating valve of the hydraulic press; chambers *D* are then refilled with molten lead from the melting pot, after which the drawing of the cable can be continued.

Naturally, the parts of the press coming into contact with the molten lead will wear out faster than others, and such parts have to be adjusted or repaired from time to time. To facilitate this work, the press has been designed in such a way that these parts can be easily removed. Bushings *B* and *E* are each made of several pieces screwed one into the other, after which the entire bushing is screwed into the press. Provision is made for taking out bushings *B* and *E* by simply giving a few turns to levers *J* and *K*, respectively. Turning of either of these levers transmits motion through a train of gears to a worm-gear *L* or *M*, as the case may be, these worm-gears being set on the bushings to provide for withdrawing them from their respective positions. By this means it is a very easy matter to remove the bushings.

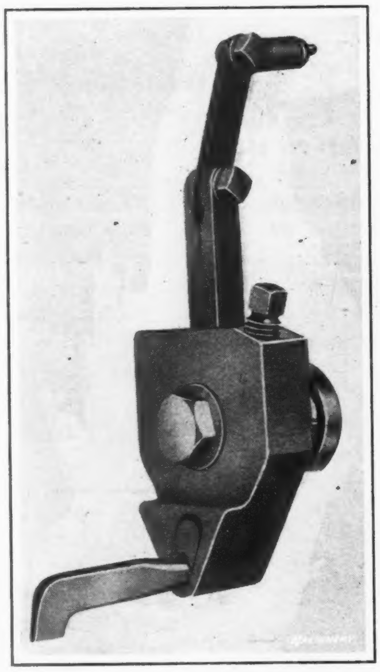


Fig. 1. Bruno Slotting Attachment for Shapers and Planers

## BRUNO SLOTTING ATTACHMENT

A slotting attachment made by the Bruno Mfg. Co., 61 Terrace, Buffalo, N. Y., for use on shapers and planers is shown in Fig. 1, and Figs. 2, 3, and 4 show applications of this attachment. It will be seen that the slotting attachment is bolted to the clapper in place of the toolpost, allowing the use of a very short stiff cutting tool, as there is no projecting toolpost in the way, necessitating the use of a long, slender tool. The tool has an adjustable friction arm riding on the head slide, which prevents vibration. All dies, jigs, gages, or other work requiring internal machining of regular or irregular shaped holes may be accurately handled with this attachment. The cutting tool is made of round or square stock and can be turned in any position so that a cut may be taken on the bottom, side, or top of the opening.

In Fig. 2 the Bruno slotting attachment is shown at work on a large die, and on work of this kind the adjusting friction arm with its buffer end effectively prevents vibration of the tool regardless of the speed. Fig. 3 shows a part of a gage which is set 10 degrees out of perpendicular by means of 10-degree parallels. The slot may be quickly and accurately done on a shaper or planer equipped with the Bruno slotting attachment. Fig. 4 illustrates the way in which a keyway may be cut in a gear and it will be apparent to any experienced mechanic that this attachment constitutes a very convenient means of handling operations of this kind.

## METZGER ELECTRICALLY WELDED PRODUCTS

The Metzger Welding Co., 1623 Blue Rock St., Cincinnati, Ohio, are manufacturing electrically welded tools and bolts of the types shown in the illustrations which accompany this description. The scarcity and consequent high price of high-speed steel makes economy in its use a matter of necessity, and by welding a high-speed steel inset to a carbon steel shank, making a tool of the form shown in Fig. 1, the benefits of a high-speed steel cutting tool are obtained at a small fraction of the cost of a solid tool made from the higher priced material. These welded tools can be retempered or reheated to any extent without the weld being impaired in any way, as the inset is secured to the tool shank by a permanent weld which has resulted in a complete union of the metals at the joint. The tools are made in six sizes, ranging from 1/2 by 1 by 6, to 1 by 2 by 14 inches.

The cap-screw shown in Fig. 2 is made by welding a head onto the body, thus greatly economizing in material through

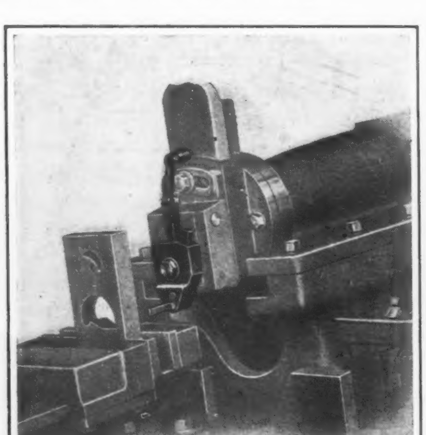


Fig. 2. Bruno Slotting Attachment working on Large Die

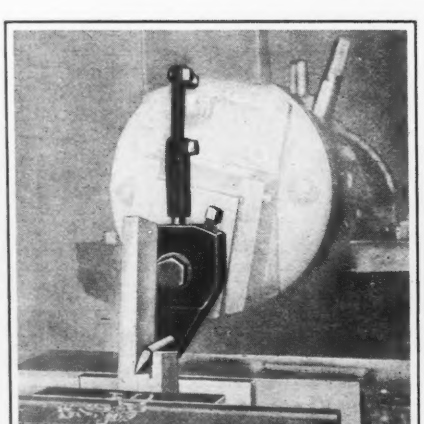


Fig. 3. Slotting a Gage with Bruno Attachment

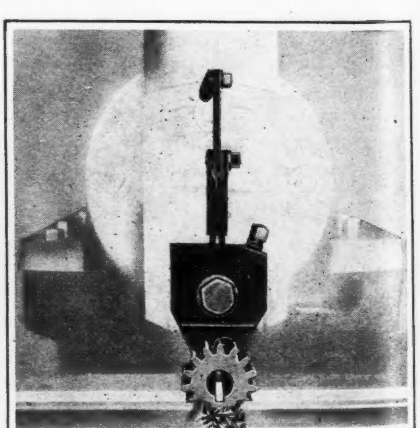


Fig. 4. How Keyways are cut in Gears with Bruno Attachment

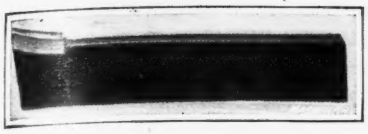


Fig. 1. Tool made by the Metzger Welding Co. by welding a High-speed Steel Inset onto a Carbon Steel Shank

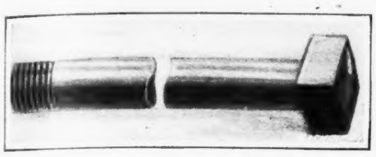


Fig. 2. Type of Cap-screw made by Metzger Welding Process

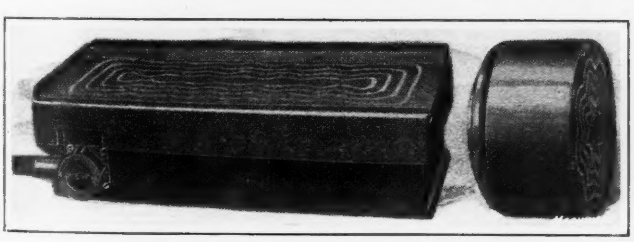
avoiding the necessity of turning away the metal from the body in order to provide for producing a head of the desired size. The heads can be made of square, hexagon, or round stock of any size, and welded to the body, which may be of any desired length or diameter. In making the weld, sufficient pressure must be applied to force the semi-molten steel together, and this expels all burnt metal and slag, leaving the structure of the metal at the joint fully as strong as that of the rest of the bolt. Bolts and cap-screws of this kind are made in a variety of sizes to meet the requirements of different users.

## WEST HAVEN PUNCHES

In the May, 1916, number of MACHINERY descriptions were published of center-punches and pin driving punches which had just been placed upon the market at that time by the West Haven Mfg. Co., of New Haven, Conn. This company is now selling sets of these pin driving punches and center-punches which are furnished in a case in which each punch is held in a separate compartment, so that any desired punch may be readily picked out. The set contains an assortment of five different sized center-punches and eight different sized punches for driving out pins or rivets; one solid driving punch, used for starting a rivet or pin that "starts hard," and one prick-punch for punching holes through thin metal.

## D & W MAGNETIC CHUCK

The accompanying illustration shows an improved design of the magnetic chuck which the D & W Fuse Co., of Providence, R. I., have been manufacturing for several years. The improvement of this chuck consists of providing a new form of faceplate in which the sections of opposite polarity are separated by bands of non-magnetic material which follow a winding path instead of being straight as was formerly the case. It is claimed that in this way greater holding power is provided for the chuck. In other respects, these chucks are similar in design to those previously made by this company.



Improved Type of Magnetic Chuck made by the D & W Fuse Co.

## SIMPLEX FOUR-JAW CHUCK

In the May, 1917, number of MACHINERY a description was published of a four-jaw chuck which had just been placed on the market at that time by the Simplex Tool Co., of Woonsocket, R. I. The design of the chuck has now been improved, and Figs. 1 and 2 show one of the Simplex four-jaw chucks of the latest model. The original chuck was made in such a way that it was necessary to thread the chuck boss to fit the spindle of the lathe, which limited the use of the chuck to lathes with the same type of spindle nose. In the improved chuck, a back-plate can be used in connection with a spigot and bolts to secure the chuck in place. The nuts and washers that were used for keeping the jaws flat in the jaw ways of the old chuck have been replaced by a special adjusting feature which is shown in the rear view of the chuck in Fig. 2. It is claimed that this chuck cannot be strained so that the jaws will not grip for their entire length, and that ample strength and gripping power are provided for work which comes within the range of a chuck of this size.

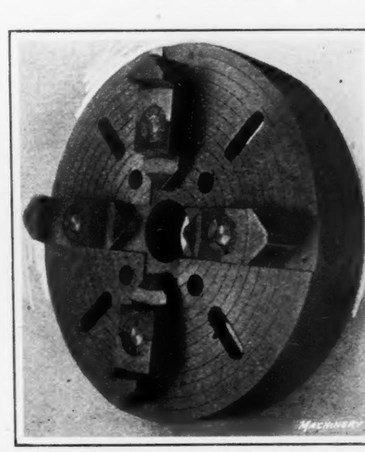


Fig. 1. Four-jaw Chuck made by Simplex Tool Co.

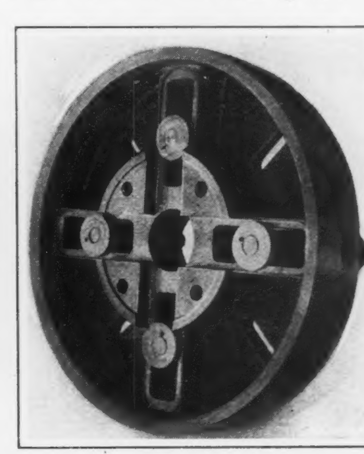
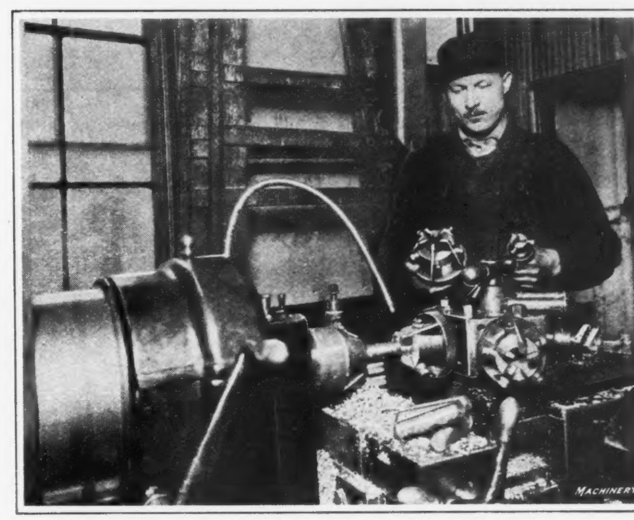


Fig. 2. Opposite Side of Simplex Four-jaw Chuck

## GENESEE ADJUSTABLE HOLLOW-MILL

The Genesee Mfg. Co., of Rochester, N. Y., are now making a line of adjustable hollow-mills of the type shown in operation in the accompanying illustration. Mills of this type are made to handle work from 1/8 inch to 2 inches, and they are made with three or more blades, according to the size of the tool. These blades are positively held by a screw acting in conjunction with a bushing which is shouldered in such a way that the bushing and screw fit into a hole on the side of each blade and pull it down into the holder. A threaded collar on the body of the holder acts as an end support for the blades, and means are provided for adjusting their position as desired. These mills are especially adapted for use on screw machines, but they may also be used on other machine tools.



Application of Genesee Adjustable Hollow-mills on Screw Machine

## FLEMING COMBINATION LATHE

To provide for the performance of turning, milling, and boring operations on a single machine, the George W. Fleming Co., 16 Broadway, Springfield, Mass., are building a combination lathe which is shown in Figs. 1 and 2. It is claimed that one of these machines has all of the facilities provided on a 16-inch lathe, a horizontal boring mill, and a plain milling machine, with the additional feature that the lathe is of the sliding-bed gap type. When in use, each unit can be operated just as readily as if it were a separate machine. The base, which carries the sliding member, is ribbed to provide a stiff construction, so that the lathe bed is supported without vibration; and the milling machine table acts as a support for the sliding bed when this bed is in the "closed" position. The sliding lathe bed is strongly ribbed, and the ways are carefully scraped to

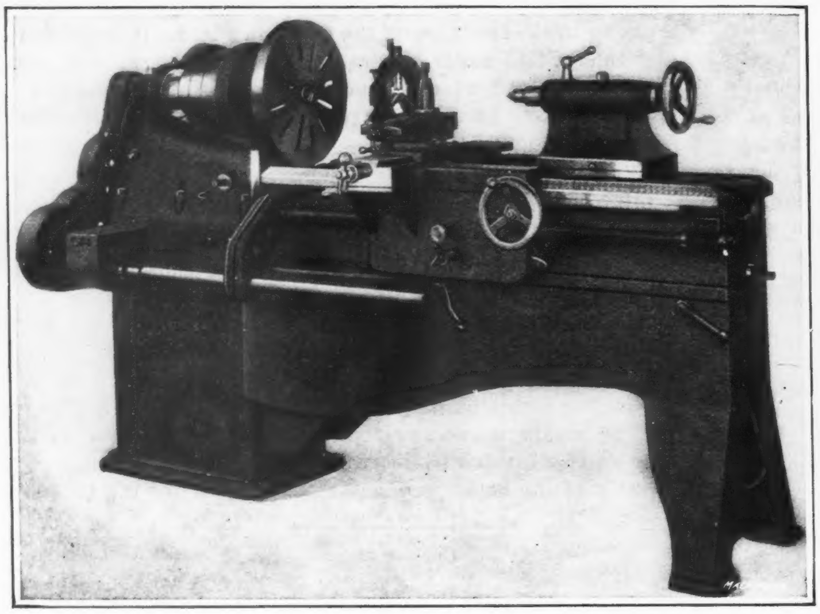


Fig. 1. Combination Lathe built by the George W. Fleming Co., arranged for Use as a 16-inch Lathe

secure accurate alignment of the spindle with both the carriage and the tailstock. The lathe carriage is made to extend out over the face of the apron to allow the compound rest to be used up to the full swing of 25 inches, when the work is of such a size that it requires the gap lathe arrangement to be used.

For driving the machine, the usual arrangement of a four-step cone pulley and single back-gears is employed, and the headstock is provided with a hollow spindle supported by carefully scraped bearings in which provision is made for taking up wear. The milling machine table, saddle, and knee are scraped to accurate fits on all sliding surfaces, and the table is elevated on the face of the column by means of helical gears and a screw. The crank for operating the table is located on the face of the column where it may be conveniently reached by the operator. On the standard machine, hand feed is provided for the milling machine table. The horizontal boring mill is of the table type, and is designed for the use of a boring-bar 1½ inch in diameter, which is furnished with power feed. The drive for the power feed is taken from the lathe change-gears. The regular equipment furnished with this combination lathe includes a countershaft, large and small faceplates, a steadyrest, a set of change-gears, one milling machine arbor, and the necessary punches for making all adjustments. The following may be furnished as extra equipment and features of design: power longitudinal feed to the milling machine table, a taper attachment, a milling machine vise, and a dividing head for the milling machine.

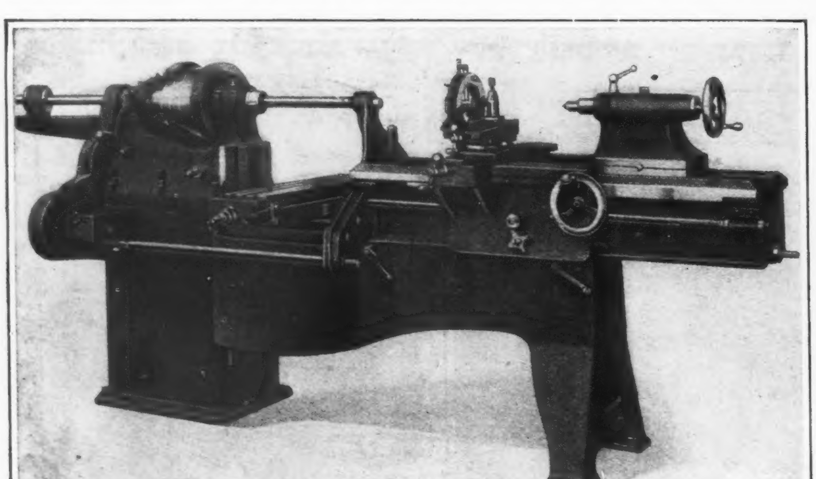
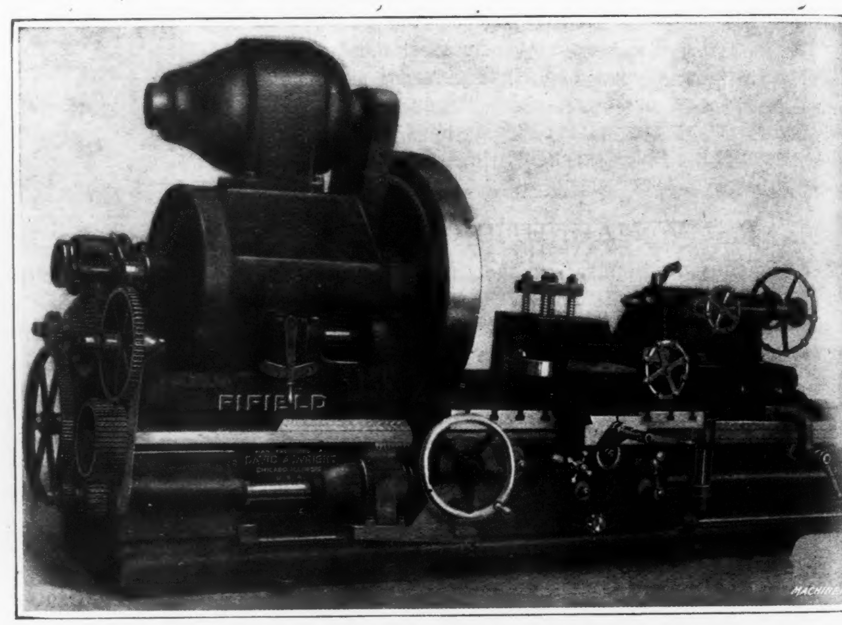


Fig. 2. Fleming Combination Lathe arranged for Use as a Horizontal Boring Mill and Milling Machine

## MOTOR-DRIVEN "FIFIELD" LATHE

In the October, 1917, number of MACHINERY an announcement was made of the acquisition of manufacturing rights for the "Fifield" heavy-duty engine lathe by David A. Wright, 568 Washington Blvd., Chicago, Ill. This lathe is now being built in a motor-driven type which is illustrated and described herewith. The range of sizes in which these motor-driven lathes are available is as follows: 34-, 36-, 40-, 50-, 60-, 72-, 84-, and 96-inch swing in standard types, and 40-, 50-, and 60-inch swing in a special heavy type. Lathes of these different sizes are built with any length of bed to meet the requirements of different shops.

In working out the design of these lathes, all gears have been guarded to prevent the possibility of injury to the operator, and all main and high-speed bearings are bushed with bronze. The bushings are securely fastened to their seats and large oil-channels are provided with oil-holes conveniently located to facilitate oiling. It will be seen that the headstock is of the all-geared type and any of three mechanical changes of speed can be obtained by manipulating a single lever. The motor mounted on top of the headstock may be supplied for connection with either alternating- or direct-current circuits and may be either constant- or variable-speed. All bearings in the headstock are of the self-oiling type, and they are furnished with large oil-wells that carry an ample supply of lubricant. The shafts and spindles are ground to size, and the bearings in which they run are reamed and scraped to a close fit.



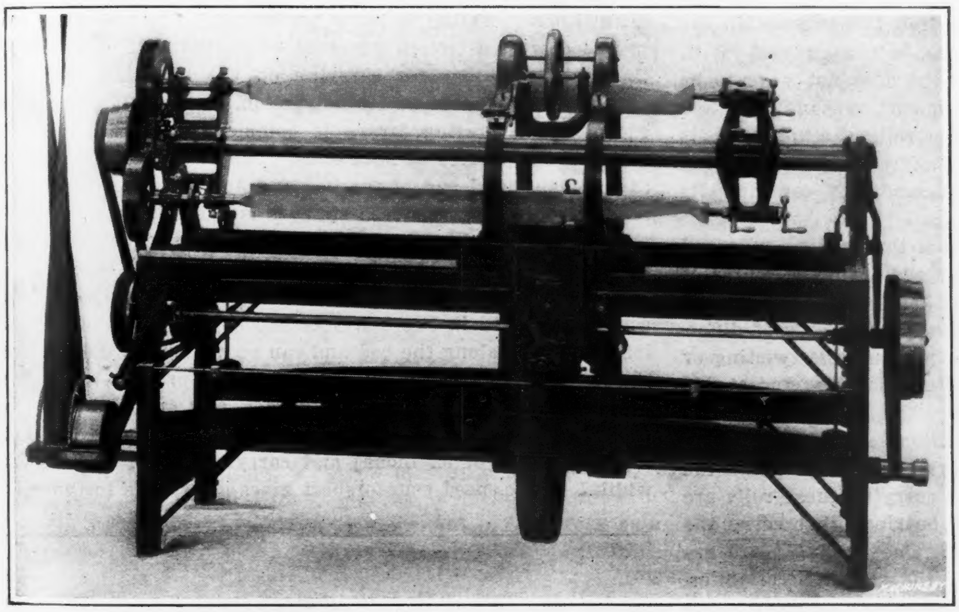

"Fifield" Motor-driven Heavy-duty Engine Lathe built by David A. Wright

The carriage is fitted to V-ways on the bed and is gibbed underneath the ways at both the front and back. A clamp provides for securing the carriage in any desired position when the cross-feed is to be employed. Power feed and hand longitudinal feed are available in either direction. The tool-slide has taper gibs furnishing means of adjustment for wear, and it is fitted with straps and bolts designed to hold large tools. When a taper attachment is used on the machine, it is secured to the carriage and bolted to T-slots on the side of the bed. The apron has a friction clutch for traverse feeding and a lead-screw nut for the perform-

ance of threading operations, with feed reverse in the apron. The feed gears are driven by a spline in the lead-screw and may be disengaged while the lathe is cutting threads. A steadyrest of box section is furnished with the lathe, and this rest has three jaws with liberal wearing surfaces. The top half of the steadyrest may be swiveled on one side and is easily removable. Cross adjustment of the upper part of the tailstock is accomplished by means of a screw, and the tailstock is operated by a crank wrench and gearing, which engage the steel feed rack for traversing the tailstock along the bed by hand. Fourteen change-gears are furnished with the machine for use in thread cutting.

## AIRPLANE STRUT TURNING MACHINE

In the March, 1916, number of MACHINERY a description was published of a rifle stock turning machine which had just been placed on the market at that time by Gilman & Son, of Springfield, Vt. In the accompanying illustration there is shown a machine of similar design which has been developed for use in turning airplane struts. In both this machine and the rifle stock turning machine, a model of the desired form is made for use in the machine and this acts as a "master" for the guide on the turning machine, which controls the operation of the tools to provide for turning the work to exactly the same form. In the illustration, the master is shown in the upper position and the partially turned airplane strut is shown in the lower position. The general features of the machine are the same as that of the rifle stock turning machine. This airplane strut turning machine is built by the Fitz-Empire Double Pivot Last Co., Rochester, N. Y., of which the firm of Gilman & Son is a branch. The carriage that supports the cutter-head can be fed in either direction, which avoids the necessity of returning to the starting point. The rate of feed is 4 to 6 inches per minute. Machines of this type are built in three sizes, with capacities of 50, 72, and 100 inches between centers.


Airplane Strut Turning Machine built by Fitz-Empire Double Pivot Last Co.

## KANE & ROACH ANGLE BENDING MACHINES

On the No. 14 angle bending machine built by Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y., light angles up to 2½ by 2½ by 1/4 inch can be bent. To provide for bending larger angles, this firm has brought out a heavy-duty machine that is built in three sizes. The No. 22 machine handles angle-irons up to 3 by 3 by 3/8 inch. The No. 23 machine handles work up to 4 by 4 by 1/2 inch, and the No. 26 machine handles work up to 6 by 6 by 5/8 inch. In addition to bending angles, these machines can be employed for bending equivalent sizes of I-beams, channels, T-irons, rounds, squares, tubular stock, flat stock, and other shapes by simply making "filling in" collars or rolls to suit any particular kind of work. It is also possible to bend either one angle or two angles at a time, according to the quantity of work which is being handled.

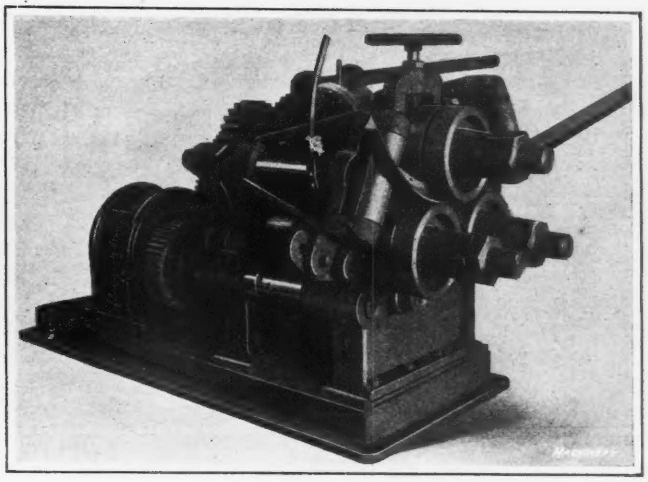


Fig. 1. Kane & Roach Angle Bending Machine equipped for Individual Motor Drive

In working out the design of these machines, the bending rolls were placed as close to the floor as possible, in order to facilitate placing heavy work in the machine. In Fig. 1 a machine is shown equipped for individual motor drive, and Fig. 2 shows the machine arranged for belt drive with reversing pulleys. In cases where belt drive is employed, the shifters are so constructed that the operator of the machine can manipulate either shifter to provide for running the machine forward or back, as required. In handling certain classes of work, it is necessary to reverse the machine several times to provide for running the work back and forth, and in such cases a conveniently located operating lever is particularly important. It will be noticed that the bending rolls are almost in contact with each other, and there are several reasons for this arrangement. In the first place, having the rolls close together practically avoids the flat or straight spot at either end of a piece that is being bent, which is an important feature, because it not only saves time in bending the ends of the work to the required curvature, but material is also saved through avoiding the necessity of crop-


Fig. 2. Kane & Roach Angle Bending Machine equipped with Reversing Pulleys for Belt Drive

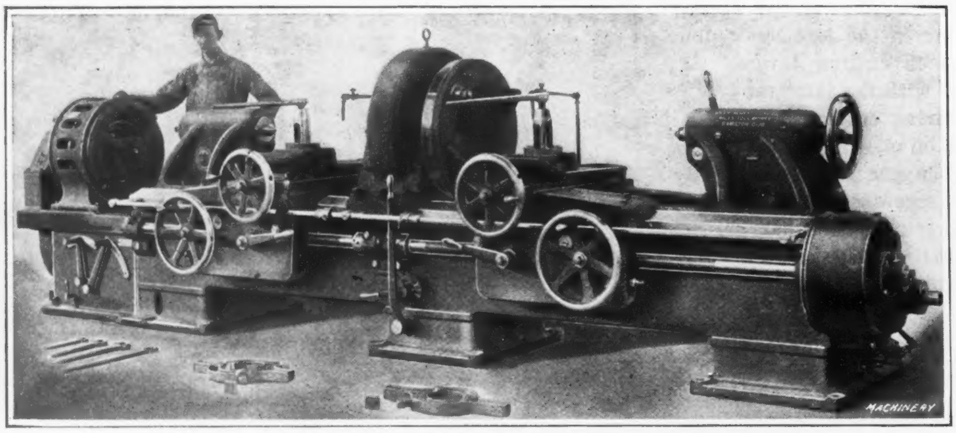



Fig. 1. Front View of Niles-Bement-Pond No. 3 Axle Lathe

ping off the extreme ends of the work which cannot be bent to the desired form. Another feature of having the rolls close together is that the material can be started into the roll to be bent without having to start the bend by hand. This is the means of making a very important reduction in the cost of bending work. A sliding gag under the adjusting screw provides for holding down the top roll, and this gag can be slid out from under the screw to enable the top roll to be raised out of the way when it is desired to put work in the machine or take it out after a bend has been completed. With this arrangement, the screw adjustment does not have to be altered. When one piece has been removed and another piece has been put into position on the lower rolls, the upper roll is dropped into place and the gag slid back under the adjusting screw, after which the machine is ready to continue its operation.

Side rolls are provided at each side of the bending rolls and these may be swiveled to any angle according to the radius of the curve to which work is being bent. These side rolls can also be adjusted in or out to meet the requirements of different classes of work. They effectually prevent side twisting or buckling of the work during the bending operation and enable the piece to come out perfectly true. The rolls are made of high-carbon steel and the outside sections slide in or out to provide for handling any width of work that comes within the capacity of the machine. The shafts carrying these rolls are exceedingly heavy and all the front bearings that carry the roller shafts are bushed with bronze. The driving gears are made of steel with cut teeth. With the exception of differences in size, the design of all three of these machines is the same. Each machine is provided with a scale and pointer to show just where to set the rolls for bending work to any desired radius of curvature, which is an important feature in simplifying the setting of the machine for any given job.

## NILES-BEMENT-POND AXLE LATHE

The No. 3 axle lathe which is shown in the illustrations that accompany the following description is one of the recent products of the Niles-Bement-Pond Co., 111 Broadway, New York City. It is intended for machining axle forgings as well as rough machined axles. It will be seen that the work is center-driven and wheel seats and journals can be simultaneously turned at both ends of car axles. The tracks for the carriage consist of a wide flat way at the back of the bed and an improved compensating V-way at the front; the vee has an angle of 15 degrees at the back and 70 degrees at the front. The form of this way is clearly shown in the end view of the machine, Fig. 2. The 15-degree angle at the back of the vee serves a double purpose; namely, it presents a thrust surface at right angles to the combined forces of the tools, eliminating all tendency of the carriage to climb under heavy cuts, and it automatically compensates for wear in both the carriages and the lathe bed.

Mention has already been made of the use of a center driving head on the lathe. This head is of massive construction, completely encloses the main driving gear, and forms an oil reservoir in which the gear runs. The head is clamped to the bed by six large bolts and it may be adjusted longitudinally along the bed. The main drive is by means of a large steel herringbone gear and pinion which are carried between the bearings in the head. The axle is driven by a steel equalizing driving plate having lugs cast integral which engage both ends of the double driving dog. By means of this driving plate crooked or irregular axles can be machined without setting up bending strains.

Two carriages are provided which have power longitudinal feeds by a right- and left-hand screw that is positively driven by gearing. Split nuts engage the lead-screw and are provided with automatic devices which release them when the carriages come into contact with set collars on a tappet rod at the front of the machine. Two clamps are provided at the front of the carriages, one of these being used for clamping the carriage to the bed when turning against shoulders and facing the ends of axles, and the other clamp is under the bridge and further decreases the tendency of the carriage to lift while the burnishing operation is being performed. The tool-slides are provided with a trough which is connected with channels in the carriage bridge for carrying off the lubricant; and the aprons are of double wall construction, so that all mechanism except the operating levers is completely enclosed and all shafts are supported at both ends. The feed gears are located at the right-hand end of the bed and are completely enclosed. A lever which controls feed changes is placed at the center of the machine within easy reach of the operator and three changes of feed are available; namely 1/16, 3/32, and 3/16 inch.

In machining axles on this lathe, the work is carried on dead centers mounted in two heavy tailstocks which are adjustable longitudinally along the bed and can be clamped in the desired positions by four large anchor bolts. To prevent slipping a pawl is provided that engages a rack cast in the bed. The lathe may be driven by a three-step cone pulley having a maximum diameter of 32 inches and carrying a belt 7 inches in width. A two-speed countershaft gives six speeds to the driv-

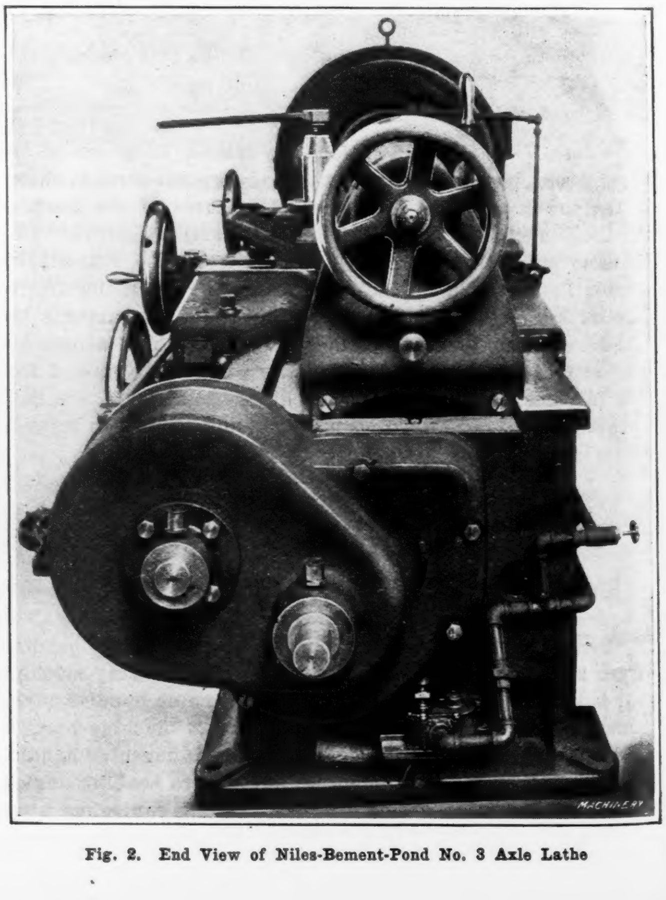


Fig. 2. End View of Niles-Bement-Pond No. 3 Axle Lathe

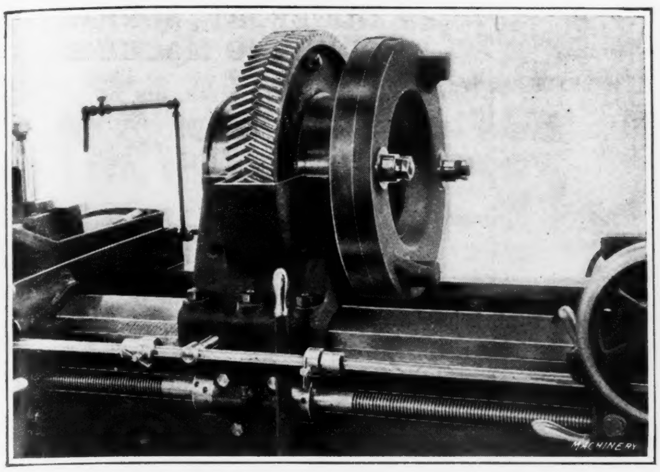


Fig. 3. Arrangement of Head to drive Work from Center

ing head ranging from 16 to 48 revolutions per minute. When so desired, single-pulley drive may be furnished and in such cases a pulley 26 inches in diameter is employed, which carries an 8-inch belt. Power is transmitted through a speed-box mounted at the left-hand end of the lathe bed which furnishes four changes of speed to the driving head, ranging from 16 to 48 revolutions per minute. A constant speed alternating-current motor may be used to drive the machine and in such cases the motor is mounted on a speed-box at the left-hand end of the lathe bed and power is transmitted by gearing from this speed-box to the driving shaft. This arrangement gives four changes of speed, ranging from 16 to 48 revolutions per minute. When so desired, an adjustable speed motor for direct current, with a speed variation of 3 to 1, may be mounted on a baseplate attached to the left-hand end of the lathe bed. This motor is geared direct to the driving shaft giving speeds to the driving head ranging approximately from 16 to 48 revolutions per minute. A crane for handling axles in and out of the lathe can be furnished as special equipment, which greatly facilitates the lifting of heavy pieces.

The principal dimensions of this machine are as follows: swing over bed, 30½ inches; swing over tool-slide, 13 inches; diameter of hole through driving head, 13 inches; maximum distance between centers, 9 feet, 3 inches; length of bed, 14 inches; diameter of tailstock spindles, 5 inches; traverse of right-hand tailstock spindle, 9 inches (left-hand tailstock spindle is stationary); number of longitudinal carriage feeds, 3; and rates of feed per revolution of driving head, 1/16, 3/32, and 3/16 inch.

## JACKSON DUPLEX DIE-SINKER

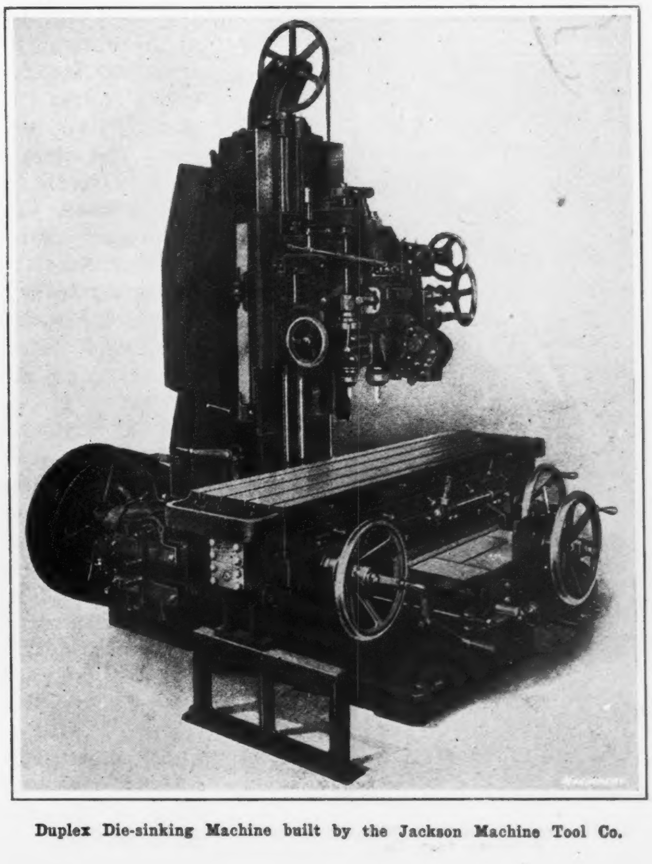
The steadily increasing use of drop-forgings in machine construction makes it important to devise methods of making drop-forging dies as rapidly and inexpensively as possible. The No. 10 duplex die-sinking machine shown in the accompanying illustration has been developed by the Jackson Machine Tool Co., Jackson, Mich., to provide for making in an inexpensive way all drop-forging dies from the smallest sizes up to those weighing 4000 or 5000 pounds each. This result has been obtained by designing the machine with all control levers easily accessible, by providing an adequate range of cutting speeds and feeds, and by having all parts so proportioned that they possess ample strength and rigidity. By reducing the cost of dies, it is possible to make machine parts of drop-forgings which would otherwise have to be made of some other material. With this die-sinking machine, it is possible to finish intricate shapes with little or no hand labor. Semicircular depressions with straight ends are easily made by one special cutter used on this machine.

Briefly described, the machine consists of a base, column, and head. On the base there is carried a cross-rail which supports the table, and to the base there is also bolted a column that carries the head. The cross-rail, table, and head are furnished with both hand and power feeds in all directions, so that a die-block bolted to the table may be brought under any of the cutting tools. A rapid traverse power feed in all directions is also available, with automatic disengagement of this feed when the rapid traverse is thrown into operation. An interlocking device prevents the rapid traverse being engaged in the same direction as the feed; this rapid traverse can be brought into operation only to back the tool out of its cut.

Cutting tools used for die-sinking are carried by two spindles. There is a large centrally located spindle in the head which carries the larger sizes of milling cutters and at the right-hand side of the large spindle there is a cherrying tool driven by suitable mechanism, by means of which narrow or wide semicircular depressions with straight or nearly straight ends can be quickly and accurately cut. The practical application of this device is for squaring up the ends of depressions in dies for shafts, etc. The range of diameters of these cutters runs from 1/4 to 4 inches, each cutter making a semicircular depression equal to its own diameter and a width equal to its thickness. A long semicircular depression may be produced from solid stock and finished with a longitudinal movement of these cutters. An interlocking device between the large spindle and cherrying tool mechanism makes it possible by the movement of a single lever to engage either one with the driving shaft and simultaneously lock the other in a stationary position. In this way danger of engaging both mechanisms at the same time is avoided.

The speed-changing mechanism is contained in a box-shaped bracket bolted to the side of the bed and nine changes of speed are obtained by means of gears sliding endwise on two shafts, the arrangement being similar to the speed-changing device of an automobile. This mechanism provides speeds ranging from 40 to 413 revolutions per minute for the large spindle and from 80 to 826 revolutions for the smaller spindle; 13 to 138 cutting strokes per minute of the cherrying tool are available. The feed-changing mechanism is similar in design and construction to the speed-box. It is bolted to the base but on the opposite side from the speed-box and nine changes of feed are provided, the range of which is as follows: In a horizontal direction, from 0.0014 to 0.0187 inch per revolution for the large spindle and from 0.0043 to 0.0562 inch per cutting stroke of the cherrying tool; in a vertical direction, from 0.0002 to 0.0031 inch per revolution for the large spindle and from 0.0007 to 0.0093 inch per cutting stroke of the cherrying tool. These feed ranges are ample for average requirements.

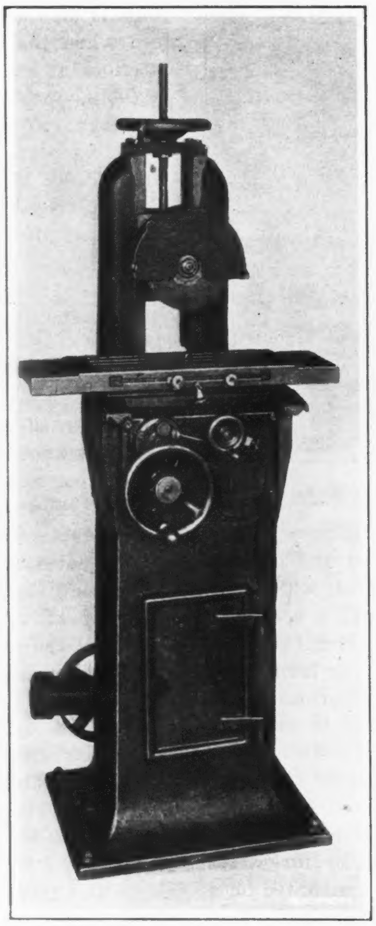
The cherrying tool and mechanism for operating it are among the most interesting features of this machine. The



Duplex Die-sinking Machine built by the Jackson Machine Tool Co.

tools are made in the form of semicircular disks and usually have a thickness which is small in comparison to their diameter. The sides of the cutter have a taper in order to enable the proper draft to be formed in the depression in the die-block. Cutting teeth are formed on the periphery and sides of the cutter, and projecting from what corresponds to the flat edge of the semicircular disk there is a round shank, which is inserted and secured in the tool-holder. This holder is a flat piece of steel of triangular shape, having a flat surface at the apex of its lower corner. In this flat surface there is a hole in which the shank of the cutter is inserted; and on each side of the tool-holder and integral to it there is a curved strip moving in circular guides in the cherrying tool housing. The center of these circular guides coincides with the center of the cherrying tool. The holder is given an oscillating motion by means of a connecting-rod attached to a projection from its upper edge, and the cherrying tool housing also has a small vertical movement, which is so timed that the cutter is lifted from the metal on its return stroke and lowered ready for the cutting stroke. When the cutter is inserted in the cutter-holder, the plane of the cutter of semi-disk form is the same as the plane of the tool-holder. An oscillating motion is imparted to the cutter corresponding to that of the holder. The center of oscillation is, of course, the center of the semicircular cutter.

When in operation, the cutter starts on its forward or cutting stroke, and at the same time it lowers into a position for removing metal from the die-block. When near the end of the cutting stroke, the cutter rises from its cutting position and remains up until it again starts on its cutting stroke. The cutter may be fed by hand or power vertically downward into its cut or longitudinally in the direction of the axis of the cutter, which is raised and lowered on its return and cutting strokes by means of a cam located inside of the head. Its action is such that the cam lifts the cutter out of the working position and a strong spring pulls the cutter into position. The strength of this spring is such, however, that the cutter cannot be overloaded by taking too heavy a cut, as the spring will yield before any damage can be done, to enable a shallower cut to be taken. In working out the design of this machine, especial attention has been paid to the location of all control levers so that they may be easily reached from the operator's position which greatly facilitates the handling of die-sinking operations.



Surface Grinding Machine built by the Bridgeport Die & Machine Co.

## BRIDGEPORT SURFACE GRINDING MACHINE

To meet the requirements of grinding work of small and medium sizes, the Bridgeport Die & Machine Co., of Bridgeport, Conn., have recently placed on the market a 5- by 8- by 14-inch surface grinding machine which is illustrated and described herewith. It is claimed that this machine is large enough to handle a majority of tool-room grinding operations, and that, as the machine is of moderate size, it occupies only a limited amount of floor space. A machine of this size also takes less power to operate. This grinding machine was originally developed for use in the Bridgeport Die & Machine Co.'s shops for use in grinding tools, dies, gages, and small machine parts. It was developed to meet the need of a small surface grinding machine which would have sufficient capacity to handle a large majority of the parts going through this company's shop which required grinding. The machine proved so satisfactory in service that it was decided to build it for the market.

The spindle is made of chrome-nickel steel, hardened, ground, and lapped, and it runs in phosphor-bronze bearings provided with means for adjustment for wear. The handwheel that provides for raising or lowering the grinding wheel is furnished with a collar graduated to read to 0.0005 inch, and the machine is equipped with a grinding wheel 7 inches in diameter by a 1/2-inch face width. The table is 24 inches long by 6¾ inches in width, and it has a working surface 14 by 5 inches in size with three 7/16-inch T-slots. The movements of the table are automatic, the range being as follows: longitudinal feed, 14 inches; cross-feed, 5 inches; and vertical adjustment 8½ inches. The net weight of this grinding machine is 575 pounds.

## AMERICAN AMPLIFYING GAGE

To meet the requirements of gaging work in either the tool-room and production departments of a plant, the American Gage Co., of Dayton, Ohio, has developed an amplifying gage which is illustrated and described herewith. In placing this gage on the market, the purpose has been to provide means of accurately and economically gaging cylindrical or flat work. One of the features of this gage is the fine adjustment that can be accurately and rapidly obtained, and another important point is the arrangement of the "gaging end," which is of small size, making it possible to measure close up to large

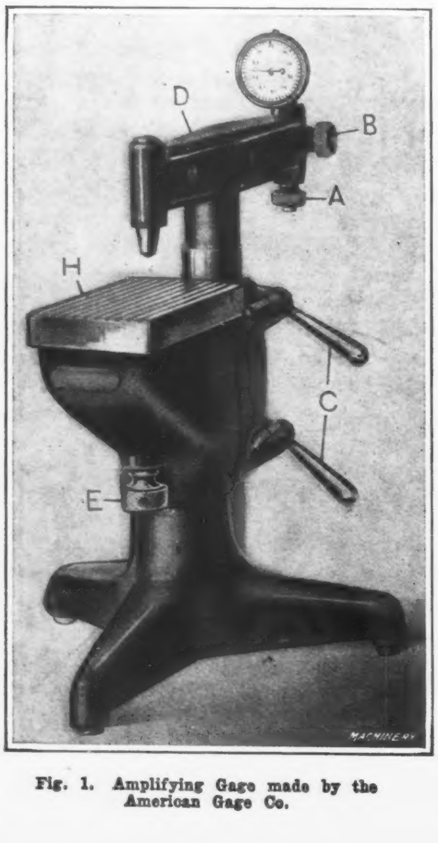



Fig. 1. Amplifying Gage made by the American Gage Co.

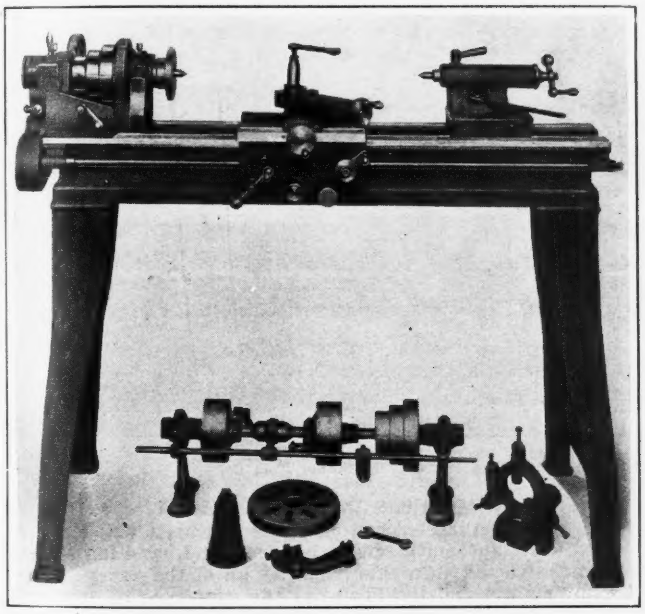
Fig. 2. Method of setting American Amplifying Gage

shoulders, etc. The amplifying levers are housed in the cross-arm, which is made of box section, providing a rigid enclosed space for these levers, from which all dust and other foreign matter is excluded.

Adjustments are made by means of screw *A*, after which clamping screw *B* is tightened to maintain the required setting. Levers *C* are used for clamping cross-arm *D*, and screw *E* provides for holding platen *H* or other attachments that may be used on the gaging machine. It will be seen that the machine is furnished with a base having a three-point bearing, which enables it to stand firmly on any bench or table. Rubber pads are provided to absorb vibration. For use on this gaging machine, an indicator is provided which is graduated to read in 0.0001 inch, with a range of 0.005 inch each side of the zero mark. A concentricity testing attachment and test centers for holding work up to 10 inches in length by 4 inches in diameter can be furnished for use with this machine. One of these gaging machines with a suitable set of master gages or models makes an ideal measuring system for use in toolrooms or in manufacturing departments where extreme accuracy is required.

## DAVIS ENGINE LATHE

The 11-inch engine lathe which forms the subject of the following description has recently been placed on the market by the C. F. Davis Machine Co., Inc., 133 Andrews St., Rochester, N. Y. This machine is well adapted for the requirements of tool and experimental shops engaged in the production of



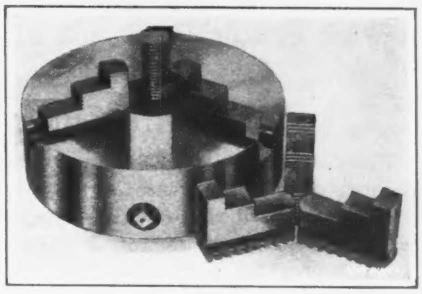
Eleven-inch Engine Lathe built by the C. F. Davis Machine Co., Inc.

small work. The spindle has a 1 3/8-inch hole extending for its entire length and is carried in babbitted bearings which are bored and scraped to fit the spindle accurately. An offset type of tailstock used on this lathe enables the compound rest to be swiveled into a position parallel with the bed, and the tailstock may be set over to provide for the performance of taper-turning operations. Longitudinal- and cross-feeds for the carriage are operated from the front of the apron and the cross-feed is graduated to 0.001 inch. A compound rest is furnished for use on the machine, which is graduated in the usual way. The regular equipment furnished with this lathe includes large and small faceplates; steadyrest and follow-rest; a countershaft and wrenches; and a full set of change-gears for cutting threads from 4 to 80 per inch.

The principal dimensions of this lathe are as follows: capacity between centers, up to 32 inches; swing over bed, 11¼ inches; swing over carriage, 6½ inches; diameter of hole through spindle, 1⅜ inch; size of front spindle bearing, 2 1/16 inches in diameter by 2¾ inches long; size of rear spindle bearing, 1⅞ inch in diameter by 1⅞ inch long; width of driving belt, 1¼ inch; ratio of back-gears, 7 to 1; diameter of tailstock spindle, 1 3/16 inch; travel of tailstock spindle, 5¼ inches; length of carriage on bed, 12 inches; travel of compound rest, 4½ inches; size of lathe tools, 1/2 by 1 inch; capacity for thread cutting, 4 to 80 threads per inch; capacity of center rest, 3 inches; range of spindle speeds, 26 to 460 revolutions per minute; and net weight of machine, 650 pounds.

## TERKELSEN & WENNBERG CHUCKS

Terkelsen & Wennberg, Boston, Mass., are now manufacturing a line of universal geared scroll chucks of the type which is illustrated and described herewith. These chucks are made with either inside jaws or outside jaws, and chucks may be furnished with two sets of jaws to provide for holding work from either the inside or the outside. A chuck provided with one of these extra sets of jaws is shown in the accompanying illustration. These chucks are made in ten different sizes with capacities of 2½, 3, 4, 5, 6, 7½, 9, 10½, 12, and 15 inches.

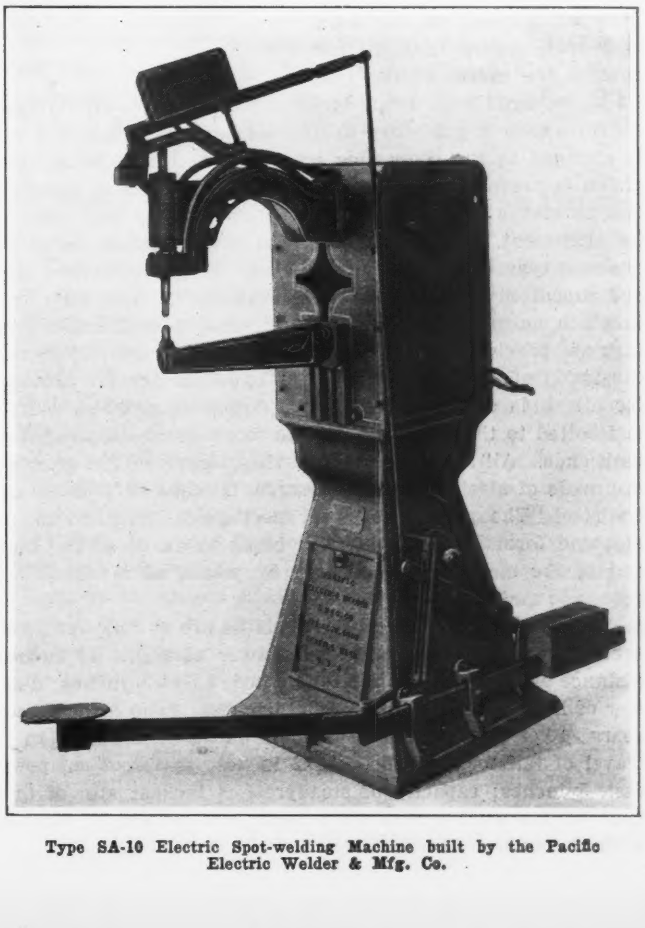


Scroll Chuck made by Terkelsen & Wennberg

## PACIFIC ELECTRIC SPOT-WELDER

The Pacific Electric Welder & Mfg. Co., Seattle, Wash., are now building a type SA-10 spot-welding machine which has a capacity for work ranging from 30 gage up to 11 gage. In other words, it is able to weld together two pieces having a combined thickness up to 1/4 inch. This machine has a depth of throat of 20 inches and the horn is adjustable through a distance of 6 inches, the maximum opening between the welding points being 3½ inches. The height from the floor to the welding points is 45 inches and the welder has an over-all height of 60 inches. Crated for shipment it weighs approximately 1000 pounds.

Machines of this type are used for performing the familiar operation of spot-welding, which is employed to electrically



Type SA-10 Electric Spot-welding Machine built by the Pacific Electric Welder & Mfg. Co.

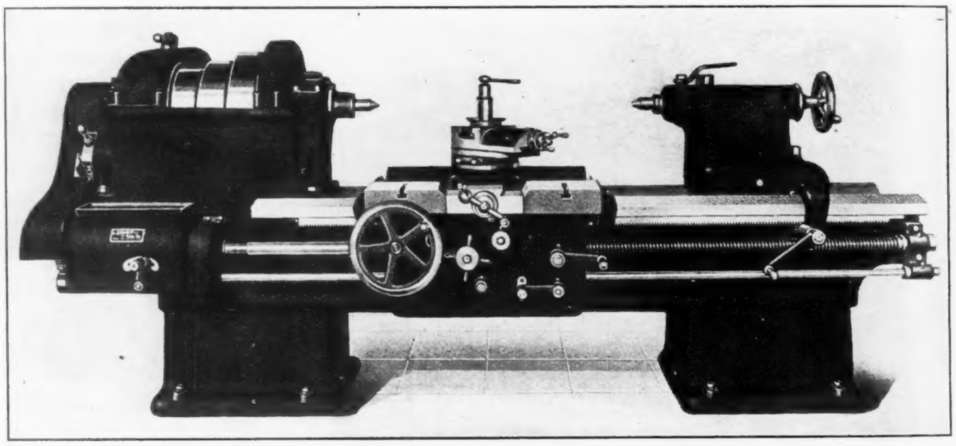
fuse together two or more metal sheets without any preliminary preparation of the stock. It is the mechanical equivalent of riveting, although spot-welding may be more quickly and, therefore, more economically accomplished. In spot-welding on one of these machines, the material is placed between the electrodes at the point where it is desired to make the weld, after which pressure is applied with the hand or foot lever, so that the metals are squeezed together. The weld is made almost instantly. Welding rods or wire in the form of a cross, etc., can also be done on the spot-welding machine. Single-phase alternating current is used in operating this spot-welding machine. Pacific electric spot-welders are made in other sizes that are adapted for welding thicker metal.

## SIDNEY HIGH-DUTY LATHE

The Sidney Tool Co., Sidney, Ohio, are now building the 25-inch, double back-geared, high-duty lathe which is illustrated and described herewith. This machine is equipped with semi-quick-change gears and a 10-foot bed, but these lathes are also provided with quick-change gears and with beds 10, 12, 14, 16, 18, and 20 feet in length. The bed is made with heavy double-wall cross-girts, spaced 2 feet apart, and one large way is cast on the bed at the front and a smaller way at the back. A 20 per cent steel mixture is used for casting these ways on the bed, thus providing a very hard metal for the carriage bearings, so that any wear which develops will be largely confined to the carriage. The carriage vee in front is 3 inches wide, and the vee in the rear is 2½ inches wide. The length of the carriage is 36 inches, and it is drilled to receive a taper attachment and also grooved to receive the tongue on the taper attachment which maintains alignment. The racks are made of high-carbon steel and secured to the lathe bed with pins and bolts.

Full-length taper gibs with end screw adjustment are provided on both the cross-slide and compound-rest slides, these gibs being placed on the negative side, where they do not receive the thrust of the tool. The compound rest is designed with a completely circular swivel which is graduated in degrees, and the compound rest is clamped to the cross-slide by means of heavy bolts. Provision is made for securing the tailstock spindle in any position by means of a clamping bolt without in any way affecting its alignment. It will be seen that the headstock is of the enclosed type, and the spindle is made of 50-point carbon steel and supported in phosphor-bronze bearings. The spindle bearings are equipped with sight-feed oil-cups, and all other bearings are provided with Brown & Sharpe oil plugs. By having the apron of the double-plate type, two bearings are provided for all studs carrying gears. The apron is grooved, pinned, and bolted to the carriage, and the feed-rods are supported on both ends. All apron gears, as well as those in the gear-box, are made of steel, and the lead-screw is made of 40-point carbon steel. The quick-change-gear mechanism furnished on this machine forms a complete unit, being mounted at the front end of the machine and secured by means of a tongue and groove to maintain alignment.

The principal dimensions of this lathe are as follows: swing over shears, 27 1/2 inches; swing over carriage, 19 inches; distance between centers for 10-foot bed, 4 feet, 6 inches; diameter of hole through spindle, 2 3/16 inches; ratio of first back-gears, 4 1/4 to 1; ratio of second back-gears, 11 1/2 to 1; travel of tailstock spindle, 10 1/2 inches; travel of compound rest, 5 inches; capacity of steadyrest, 8 inches; size of tools used on machine, 7/8 to 1 3/4 inch; and weight of machine with 10-foot bed, 7000 pounds.



High-duty 25-inch Engine Lathe built by the Sidney Tool Co.

## NEW MACHINERY AND TOOLS NOTES

**Shell Conveyor:** Lamson Co., 100 Boylston St., Boston, Mass. A shell conveyor of the gravity type, which is furnished with rollers that are "spool" shaped, furnishing a channel down which shells can run lengthwise. To insure ease of operation, ball bearings are used to carry the roller spindles.

**C-clamp:** William G. LeCount, South Norwalk, Conn. A line of drop-forged C-clamps provided with a screw made of high-grade steel hardened and tempered, with United States standard threads. These clamps are made in seven sizes, varying in length from 3 to 12 inches, all sizes having a throat depth of 3 inches.

**Planers:** Amalgamated Machinery Corporation, Chicago, Ill. Planers especially built for use in planing the beds of large gun boring machines. The beds of these planers are made of reinforced concrete. Although these are special-purpose machines, the same method of construction could be applied in building standard planers.

**Motor-driven Scrapers:** Modern Mfg. Co., Bridgeport, Conn. A motor-driven equipment developed to obviate the necessity of scraping aluminum and brass castings by hand. The outfit consists of an electric motor and a flexible shaft that drives the scraping tool, which may be of a variety of forms to meet different requirements.

**Moisture Separator for Compressed Air Lines:** Griscom-Russell Co., 90 West St., New York City. A device designed to remove moisture from compressed air carried in pipe lines in an industrial plant. This device operates similar to a steam separator and is particularly adapted for use in air lines serving sand-blast machines and pneumatic tools.

**Turret Screw Machine:** Defiance Machine Works, Defiance, Ohio. A No. 4 turret screw machine equipped with a geared friction head, automatic chuck, bar feed, and hand longitudinal feed to the cut off. On this machine, all of the gears are completely enclosed and the head has the cone type of drive with friction back-gears, giving two spindle speeds for each step on the cone-pulley; that is to say, a total of six speed changes.

**Electric Truck:** Elwell-Parker Electric Co., Cleveland, Ohio. An industrial truck equipped with electric motor drive, which is designed on the four-wheel steer and two-wheel drive principle. This is known as a type WB truck. Three changes of speed are obtainable in either direction, ranging from 400 to 650 feet per minute, and the truck has a capacity for loads up to 4000 pounds.

**Cylinder Grinding Machine:** Baxter D. Whitney & Son, Winchendon, Mass. This company has recently purchased from the Brown & Sharpe Mfg. Co., the manufacturing rights on its No. 23 cylinder grinding machine and will take up the building of this machine for the market. With the manufacturing rights, the Whitney Co. has acquired the designs, and the jig and fixture equipment used in making the grinder.

**Gun Boring Lathe:** Amalgamated Machinery Corporation, Chicago, Ill. A line of gun boring lathes which are made in three sizes; namely, a No. 26 machine which has a 6-inch spindle and swings 27 inches; a No. 46 machine, which has an 8-inch spindle and swings 39 inches; and a No. 56 machine, which has a 10-inch spindle and swings 48 inches. These machines are adapted for the performance of boring operations on field guns.

**Crane Cab Heater:** Cutler-Hammer Mfg. Co., Milwaukee, Wis. This company has recently applied the electric heater of its manufacture for use in warming crane cabs during severe winter weather. In this way the crane operator is enabled to

work under comfortable conditions. These heaters are also being used in gas valve houses, meter houses, on the charging bridges of coke ovens, and in other similar locations.

**Universal Milling Machine:** Becker Milling Machine Co., Hyde Park, Mass. A No. 3 universal milling machine that is driven by a three-step cone-pulley and back-gears which are located at the rear of the machine. The range of power feed movements on this machine are as follows: Longitudinal, up to 30 inches; cross, up to 10 inches; and vertical, up to 19 inches. The maximum distance from the center of the spindle to the table is 19¼ inches.

**Locomotive Gantry Crane:** Brown Hoisting Machinery Co., Cleveland, Ohio. A crane having a capacity of thirty tons, which is used for unloading materials and carrying them around a shipyard. It has a fixed boom 30 feet long and travels on the top of the gantry on tracks spaced 22½ feet between centers. The span of the gantry is 40 feet, which is sufficient to reach over three railroad tracks, and a clearance of 20 feet is provided over the rails.

**Shell Lathes:** Gisholt Machine Co., Madison, Wis. A 16-inch lathe for machining shells, that has been designed to meet simplified conditions of operation in the manufacture of high-explosive and shrapnel shells. This is a single-purpose machine enabling the design to be greatly simplified, and thus making the machine well adapted for operation by female labor. Various auxiliary equipments are furnished for this lathe to adapt it for the performance of various machining operations that must be performed on shells of different types.

**Reclaiming Tang:** Mailometer Co., Detroit, Mich. A device for reclaiming cutting tools from which the tang has been twisted off. The device consists of a new tang which is provided with a shoulder so that the shank of the tool to be reclaimed can be ground to fit this shoulder. In this way, the tool is provided with a new tang enabling it to be fitted into the commonly used forms of drill sockets, or mounted directly in the machine spindle. It is claimed that the new tang has exactly the same driving power as the one originally provided on the tool.

* * *

## ELECTRIC HOIST MANUFACTURERS ASSOCIATION

The Electric Hoist Manufacturers Association has recently been organized with the object of coordinating the total experience of the electric hoist manufacturers of the United States and making available for the user the best in electric hoist design and practice. The association holds monthly meetings for the purpose of studying the specific needs of the hoist user and promoting the standardization of electric hoists. The War Industries Board has requested information concerning the ability of the electric hoist manufacturers to handle the volume of business offered them, and it is thought that the association can be of great assistance to the Board. The members of the association are: Brown Hoisting Machinery Co.; Detroit Hoist & Machine Co.; Euclid Crane & Hoist Co.; Franklin-Moore Co.; Link-Belt Co.; Roeper Crane & Hoist Works; Shepard Electric Crane & Hoist Co; Sprague Electric Works; and Yale and Towne Mfg. Co. The officers are: F. A. Hatch, chairman, Shepard Electric Crane & Hoist Co.; F. W. Hall, vice-chairman, Sprague Electric Works; and C. W. Beaver, secretary-treasurer, Yale & Towne Mfg. Co. The membership of the association is confined to those engaged in the manufacture of monorail electric hoists.

* * *

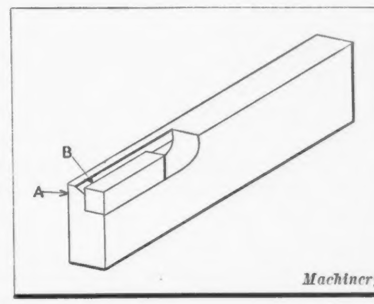
## LONG SERVICE WITH SAME CONCERN

In these days when we hear so much about labor turnover, it is interesting to note that there are instances where employes remain for a long time with the same company. The C. C. Bradley & Son, Inc., Syracuse, N. Y., have had a satisfactory experience in keeping many of their employes for a long period of time; thus, for example, there are seven men in the Bradley shops who have been with the concern for over forty years; four who have been with them from thirty to forty years; eight, from twenty to thirty years; and seven, from fifteen to twenty years; or, in all, twenty-six men who have been with the concern for over fifteen years. It is also interesting to note that the sons of many men who are now working in the Bradley shops are also employed there, and, indeed, some of the grandsons of employes have also been working in the shops. The labor turnover is apparently not a problem with this concern.

## BRAZING STELLITE TO STEEL SHANKS

The accompanying illustration shows a method of brazing stellite to steel shanks. A thin web *A* is left on the side of the shank opposite the cutting edge of the bit; the thickness of this web is governed of course, by the width of the bit, and it should be chamfered, as shown at *B*, at about 45 degrees and to a depth of approximately one-fifth the depth of the bit. Leaving this web insures enough copper in the joint prior to lifting the tool from the fire.

The stellite tip and shank are placed in the forge and allowed to soak in the fire until white-hot, when a thin sheet of copper should be placed between the steel shank and the stellite tip, borax being freely applied. The tool is then brought to a white heat, or to such a point that it will soften the stellite slightly, additional copper being melted from time to time, either from a piece of copper tube or copper sheet, and allowed to flow in the chamfer *B*. In this way the copper will run down and wash away any dirt, and at the same time exclude the air and do away with oxidation. When the tool begins to soften slightly, it should be removed from the fire and squeezed slightly in a vise or with a pair of tongs.



Method of brazing Stellite to Steel Shanks

The process is entirely practicable, but it requires some little practice, and a person should not be discouraged if his first braze is not all that he could wish. Tools made in this manner are capable of standing any stress up to the point of breaking the shank. It follows, of course, that the short end of bar stock can be entirely used by following this method.

* * *

## CONVENTION OF AMERICAN GEAR MANUFACTURERS' ASSOCIATION

The second annual convention of the American Gear Manufacturers' Association will be held at Green Brier Hotel, White Sulphur Springs, W. Va., on April 18, 19, and 20. The principal subject of discussion will be the standardization of gearing. The hardening and heat-treating of gears will receive attention, and papers will also be read on uniform cost accounting and on hobs and hobbing machines. An address by a representative of the United States Chamber of Commerce, of which the association has just become a member, will also bring matters of timely interest before the association.

* * *

## SAFETY PRECAUTIONS IN DROP-HAMMER OPERATION

The National Safety Council has issued some rules relating to the safe working of steam hammers and drop-hammers which, if followed, would minimize the number of accidents in forge shops to a great extent. The most important of these rules are as follows: Shut off all power and wait until the moving parts come to a standstill before oiling or cleaning the machine and before adjusting any part of the machine. Be sure that all parts of the body are out of the path of the hammer when the treadle is operated by foot. Use a screen guard in back of the drop to prevent sparks flying. When adjusting the dies, keep the foot off the treadle. Before tripping the treadle, see that no person is working on top of the drop. Keep sprue cutters in proper adjustments to prevent breaks and injury to the operator from flying parts or fragments. When putting work into the die, keep the mind and eyes on the operation.

* * *

**The total amount of money in the United States at the beginning of 1918 was estimated at $6,256,198,271, or an increase of $1,244,000,000 during the year 1917. The per capita circulation on January 1, 1918, was estimated at $48.76, as against $43 a year before.**

# VERTICAL AND OVERHEAD WELDING BY THE OXY-ACETYLENE PROCESS[1]

BY S. W. MILLER[2]

Recently, the statement was made that the electric-arc metallic electrode was the only means by which vertical and overhead welding could be done. But every experienced oxy-acetylene welder knows that both vertical and overhead oxy-acetylene welding are being done in hundreds of shops and that much work could not be done if such welding were impossible by this process. The oxy-acetylene process is used for repairing locomotive firebox sheets—welding cracks and applying patches—yet the work on the side and flue sheets and back heads, as well as the work of welding the flues to the flue sheets, is entirely on vertical surfaces. Many shops apply new side sheets by this process, when overhead welding is necessary in the case of radial stay construction, while almost all automobile frame breakages have at least part of the weld thus made. However, overhead welding should not be resorted to unless necessary. It is more usual to weld steel in these ways than other metals; but a really expert welder is able to handle cast iron, brass, and aluminum. In the case of heavy castings much handling of hot castings can be avoided if the operator is able to weld vertically and overhead.

The feasibility of this work depends on the surface tensions of the metal and the slag on its surface; the temperature range of partial solidification of alloys on cooling from the liquid state, which may be called their freezing range; the fact that pure metals solidify instantly as soon as the proper temperature is reached, so that they have no freezing range; and the heat-conducting power of the metal. That liquids have a surface tension is easily seen by drawing a needle between the fingers to give it a slight coating of oil, and then laying it carefully on the surface of the water in a dish. Not only will the needle float, but its weight will depress the surface of the water so that the needle will lie in a hollow. It will be found that quite a little force is needed to make the needle break through the water surface, although when it does it at once sinks to the bottom. This supporting property is possessed, to some degree, by all liquids, including molten metals and it is for this reason that all liquids form into round globules when in small quantities. All pure metals, on cooling from the melted state, solidify instantly as soon as their freezing temperature is reached; alloys, however, solidify gradually through a range of temperature. Thus pure iron solidifies at 2730 degrees F., while steel containing 1 per cent of carbon, which is an alloy of carbon and iron, begins to solidify at about 2600 degrees F. but is not entirely solid until 2175 degrees F. If one end of a cast-iron rod and one end of a copper rod of the same diameter and length are heated in a fire, the other end of the copper rod will become hot much sooner than will the other end of the iron rod, because copper is a better conductor of heat than cast iron. It is clear then that more heat will be required to weld a copper piece than a cast-iron one of the same size, because, while their melting points are not very different, the conducting power of the copper is much higher and the heat is taken from the weld faster.

Everyone who has tried knows that it is much harder to weld vertically and overhead than in the usual way and that overhead work is the harder of the two. The difficulty also increases as the fluidity of the molten metal; that is, steel is the easiest to weld, then come aluminum, cast iron, and brass. A comparison of the factors that affect the welding of cast iron and steel is shown in the accompanying table. While the effect of these factors is not equal, the comparison shows that steel is the easier to weld overhead.

When a small area of steel is melted, the good heat conductivity of the metal tends to prevent this melted area from becoming too great; so the high surface tension acting on a small amount of molten metal tends to prevent its running away, which tendency is increased by the rapid solidification. The surface tension of the slag has but little effect, because its melting point is lower than that of steel.

When a small area of cast iron is melted, the poor heat conductivity tends to hold the heat in the vicinity of the melted part, which with the large range of solidification, makes it hard to keep the molten metal in place. The slag has a higher melting point than the metal, and its high surface tension helps to keep the metal from running away. Any welder knows that if he uses flux on overhead cast-iron welding, he cannot keep the metal in place because the flux makes a slag melting at a low temperature and exposes the metal. If too much metal is melted, its weight will exceed the surface tension of the metal and it will drop away. The blast from the torch and the breaking of the slag film with the welding rod also increase the trouble. On the other hand, the great solidification range makes it unnecessary to heat cast iron to so high a temperature, in the same way that a plumber succeeds in wiping a solder joint. If it were not for the pasty condition of the solder, which is due to part of the alloy being melted while the rest is not, such a joint could not be readily made. If the metal to be welded is preheated until very hot, a smaller torch tip and less blast will be required, a smaller area of metal will be melted, and there will be less weight to break down the surface tension of the slag and metal.

In the case of cast aluminum, the range of solidification of the usual aluminum-copper alloys is large and the surface tension of the oxide (slag) covering of the melted metal is very great. Every welder of this material knows that the oxide film is so strong and persistent that it has to be broken with a puddling rod in order to get the metal to unite; also, its heat conductivity is high, so that in the writer's opinion, it is the easiest metal, aside from steel, to weld overhead.

OVERHEAD WELDING QUALITIES OF CAST IRON AND STEEL

| Factors Affecting Welding | Steel | Cast Iron | Effect on Overhead Welding of | |
|---|---|---|---|---|
| | | | Steel | Cast Iron |
| Surface tension of metal | High | Low | Good | Bad |
| Surface tension of slag | Low | High | Bad | Good |
| Range of solidification | Small | Great | Good | Good and Bad |
| Heat conductivity | Good | Bad | Good | Bad |

*Machinery*

The overhead welding of brass (the term brass here includes all metals having copper as a base) depends so much on the composition of the alloy that it is not possible to say much about the subject. As a general rule, it is a difficult matter, although with a proper welding rod and proper handling a fairly good job may frequently be made. The quality of the welding rod has probably more to do with the successful welding of these alloys than in the case of any other metal, although some of the alloys cannot be successfully welded even when the weld is on top, let alone overhead.

The usual good welding methods and ordinary welding materials do not permit of as good results in overhead welding as in ordinary work. Usually, good welding practice requires a large pool of molten metal, so that the slag can rise to the surface, the use of proper fluxes in the case of cast iron and brass, and of a welding rod of lower melting point than the original material; all of these are opposed to the conditions of overhead work. The best results can be obtained by thoroughly preheating the parts, using no larger a tip than is necessary, avoiding the use of flux, keeping as small a pool of molten metal as possible, keeping the metal as far from the upper part of the solidifying range as is consistent with a good union, (that is keeping it in a partly pasty condition), and keeping the welding rod in the molten metal. To meet these conditions requires great skill, which can only be acquired by experience.

* * *

An association of machine tool importers has been formed in France to guard the interest of its members and to afford the necessary cooperation with the Government for the proper distribution of machines needed in national defense. Membership in the association is limited strictly to individuals, firms or companies of allied nationalities.

[1]For information on this and allied subjects previously published in MACHINERY, see "Autogenous Welds of Boiler Plates," September, 1917, and articles there referred to.

[2]Address: Rochester Welding Works, 406 Orchard St., Rochester, N. Y.

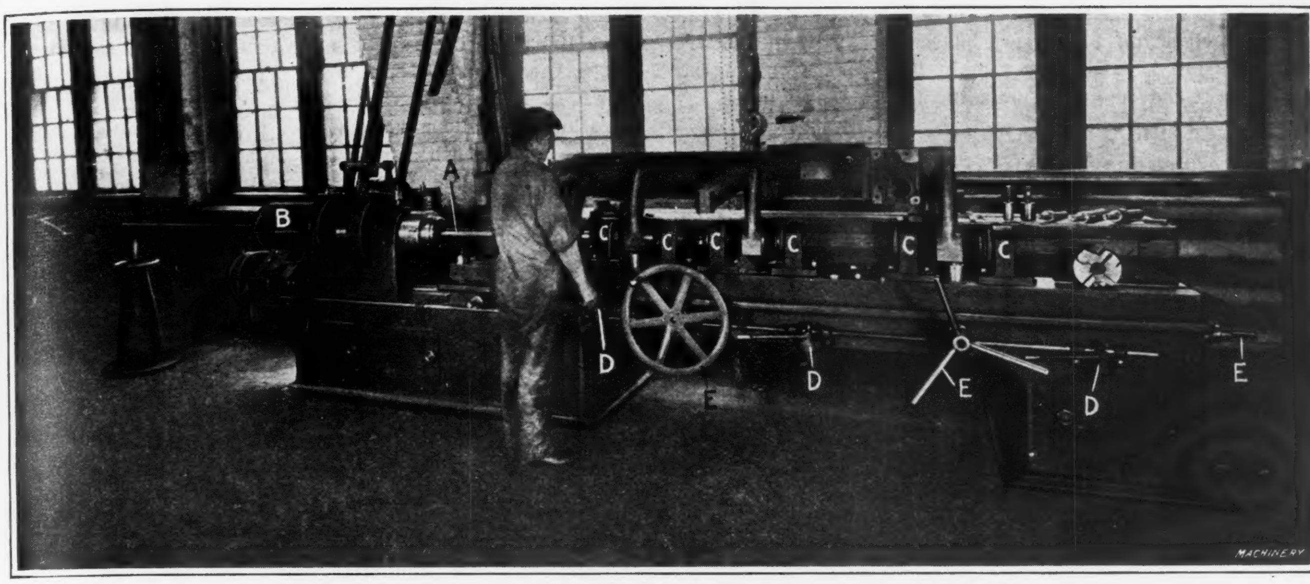



Fig. 1. Horizontal Boring Machine designed for boring Camshaft Arms of Automatics

## SPECIAL HORIZONTAL BORING MACHINE

BY J. P. BROPHY[1]

In all lines of business it is sometimes impossible to purchase a machine suitable for the work under consideration. Some time ago, when it was necessary to procure a machine for boring the camshaft arms of the Cleveland automatics, it was impossible to find a machine that would perform this operation on all the sizes of automatics, or that could be changed over for this work. This made it necessary to design a machine, as shown in Fig. 1, that would bore the camshaft arms for all the sizes of automatics from the 3/8-inch up to the 7¾-inch size. The aim when designing this machine was to simplify in the extreme, thus doing away with any possibility of mistakes in measuring by the operator, with the result that the machine shown is fool-proof in this respect.

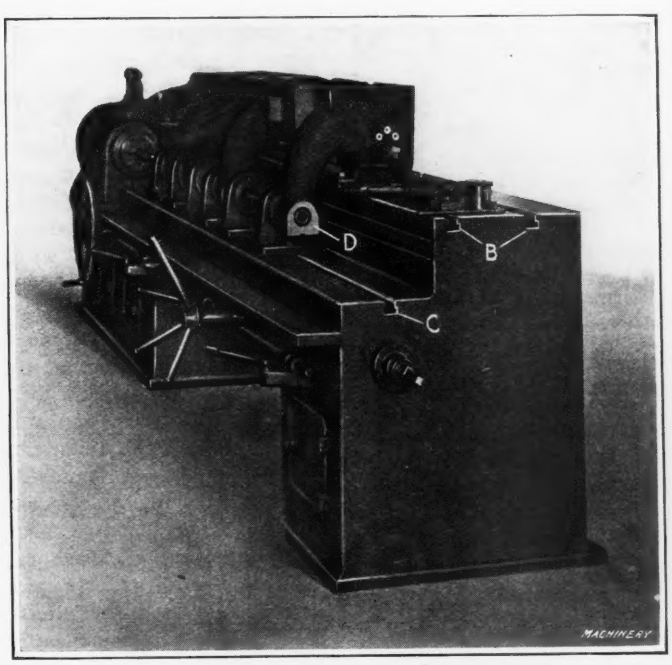



Fig. 2. End View of Horizontal Boring Machine

With this machine, it is possible to obtain different speeds for the boring-bars, which can be fed in either direction, in the boring operations. As shown in Fig. 2, the top of the bed has two plain surfaces with slots *B* and *C* running the entire length. In order to use the machine for all sizes of automatics, the different shaped elevating blocks shown in Fig. 3 are employed. These have a tongue on the bottom that fits the bed of the boring machine, and a tongue on the top that fits the bed of the automatic. Each block is marked for the size of automatic machine with which it is to be used. When these blocks are clamped in position on the bed, the camshaft arms of the automatic machine that they support drop down to the correct position in front of the steadyrests *C*, Fig. 1. These steadyrests carry hardened and ground bushings, and the boring-bars are made from high-carbon steel and are ground. Bars are provided for the different sizes of machines and the cutters are correct for each size of hole; each bar is marked for the machine on which it is to be used.

A hinged facing head *F*, Fig. 1, may be placed on the boring-bar in any position in a short space of time and clamped ready for the facing operation, as shown at *D*, Fig. 2. The spindle head *B*, Fig. 1, carries the boring-bar *A*; on the end are change-gears, similar to those on a lathe, that control the feed of the different boring-bars. The boring-bars have a longitudinal movement. The spindle head *B* can be moved horizontally 15 inches and clamped in any position desirable; this adjustment makes it possible to bring the boring-bar into the proper location in setting up. The operator can handle the boring-bar in either direction when setting up and locating the tools in their correct position from any of the positions marked *E*. Levers *D* along the front of the bed throw in the clutch for operating the feed; these clutches are placed in different positions to save the operator walking back and forth, thus saving time.

The elevating blocks, Fig. 3, are accurately made, and when the operator desires to change, for instance, from a 3/8- to a 2-inch machine all he has to do is change the elevating blocks. Then the machine camshaft arms locate themselves by the finished surface where the spindle and turret heads are located.

The end view, Fig. 2, shows the design of the bed, which is very heavy and properly ribbed to do away with springing.

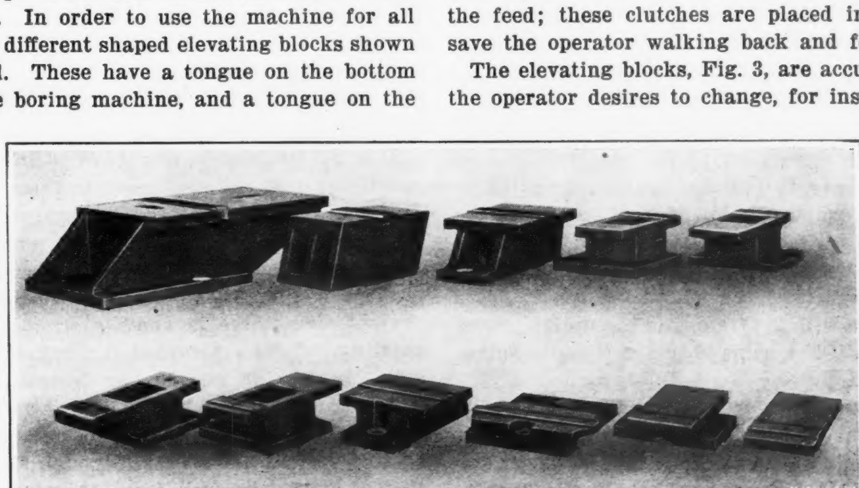


Fig. 3. Adjustment Blocks used on Horizontal Boring Machine

[1] Vice-president and General Manager, Cleveland Automatic Machine Co., Cleveland, Ohio.

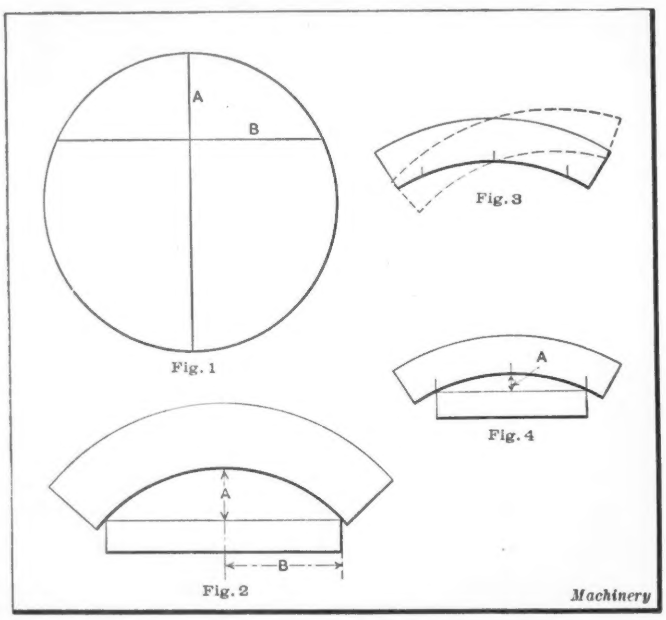
As there are only plain surfaces there is practically no wear. After the elevating blocks are placed in position and the steadyrests are located, they remain fixed, as the boring-bar furnishes the movement for finishing the camshaft holes.

* * *

## FINDING THE RADIUS OF A CONCAVE ARC

BY GUY H. GARDNER[1]

A carpenter needed to know the radius of a concave arc on a piece of work. To the eye of a machinist who was an interested spectator, it appeared to be something like 2½ or 3 feet, so he was not surprised to see the woodworker replace his center-square in the chest after a moment's consideration of its inadequate length. While the bystander wondered whether an extemporaneous tool of wood was to be made, the object of his curiosity was engaged in profound meditation. As his subsequent procedure showed, he had some acquaintance with plane geometry, but accurate and reliable recollections of his knowledge responded but slowly to his call. Realizing with how much greater facility the human mind deals with the concrete and visible than with the abstract and immaterial concept, he seized a convenient bit of board, on which he drew the diagram shown in Fig. 1; then, evidently remembering that "When two chords intersect in a circle, the product of the segments of one equals the product of the segments of the other," he thus calculated:




**Figs. 1 to 4. Method of finding Radius of Arc**

$$A(2R - A) = B^2 \qquad 2RA - A^2 = B^2 \qquad 2RA = B^2 + A^2$$

$$R = \frac{B^2 + A^2}{2A}$$

Having now provided a firm mathematical foundation, the next step was to get a straight bit of board, which he made 18 inches long, marking its center of length with his jack-knife. Laying this against the arc and measuring from its center the distance $A$, Fig. 2, which he called 1⅜ inch (though it was somewhat greater according to the machinist's later calculations), he was ready to find the length of radius by substituting this value and the half-length of his board for $A$ and $B$, respectively, in his formula. He found it to be about 30.14 inches. Driving two nails at points 30⅛ inches apart through a strip of wood, he laid the job on the bench, found a center and tried the arc with his tram. As the radius proved too long, he moved one nail to a point 30 inches from its fellow, and success was his.

The writer once saw an inspector in a machine shop tackle a similar problem. He had a number of pieces the radius of whose (concave) arc should have been 7.875 inches. The number of pieces was so small that it was not thought worth while to turn up a templet by which to try them. His plan was to clamp each in turn to a cube on the surface plate and scribe three lines 1½ inch apart with a height gage, as shown in Fig. 3, then turn the cube over, bringing it into the position shown in Fig. 4, when the height of the middle line above the others would, he thought, give the dimension $A$. Further thought convinced him that this plan would work only if the part were in exactly the proper position. If, for instance, it occupied the position indicated by the dotted lines in Fig. 3, the chordal distance would not be exactly 3 inches, and his conclusions in regard to the length of radius would be unreliable. He, therefore, clamped to the cube a parallel, as in Fig. 4, leveling it by the height gage and indicator. Then each part could be laid on the parallel and the distance $A$ measured.

In this, as in all machinists' work, much depends on the accuracy of the tools used, the trueness of the corners of the parallel being of especial importance in this case. Moreover, while for certain radii a slight error in $A$ may be negligible, in other cases a fraction of a thousandth inch corresponds to a considerable variation in the length of the radius. Evidently the inspector in the case cited, needing to know only whether or not the radius of the piece was that called for by the drawing, did not need to follow the carpenter's method of calculation, but had merely to know what $A$ should be, and then determine its accuracy or inaccuracy.

[1]Address: New London, N. H.

* * *

## PICKLING SHIP STEEL

BY MARK MEREDITH[1]

The preparing, or pickling, of ship steel is becoming more common than heretofore. Whatever compounds may be used for coating steel, it is very necessary that the mill scale be thoroughly cleaned from the plates and the bars beforehand. The British Admiralty specifications require the removal by immersing the steel for some time in a bath that contains one part of hydrochloric acid to nineteen parts of water. When the steel is taken out, fresh water is poured over it from a hose as it is scrubbed with steel brooms. The material is then coated with linseed oil and exposed to the effects of the weather for some days. In merchant ship work, this has usually been considered an unnecessary expense. The usual practice is to put the material together without removing the mill scale and allow it to rust until the ship is ready for painting. The rust and scale are then scraped off and the paint applied. The underwater part of the ship is not painted before the ship is launched, and the sea water accelerates the rusting, with the result that when the vessel is placed in drydock a very good surface can be obtained for the application of the anti-corrosive paint.

There are three principal methods of cleaning forgings, namely, pickling, tumbling, and sand-blasting. Pickling is much better than sand-blasting, for all the surfaces are cleaned thoroughly from oxides or foreign substances that are detrimental to the machining operation, while in tumbling and sand-blasting fine sand is hammered into the surface. As a result, the cost of machining is three or four times as great for a forging cleaned by sand-blasting as for one cleaned by pickling. In addition, drop-forgings that have small holes or indentations are not properly cleaned except by pickling. It has been found that the additional cost of pickling is more than offset by the saving in the cost of machining.

It is not uncommon nowadays to find merchant ship owners specifying that the steel used in their ships shall be pickled. It is well known that the rusting process is not absolutely effective, and the extra expense of pickling is probably easily saved in the smaller amount of corrosion occurring and consequent smaller upkeep cost for the renewal of steel. At the present time there is another strong argument in favor of pickling. Ships are rushed through very quickly and, if possible, drydocking near or on completion is dispensed with. This means that the bottom of the vessel has to be properly painted before it leaves the stocks, and it is doubtful if the rusting process has gone far enough to insure a good application of paint. In such cases, therefore, it is better to be on the safe side and pickle the steel before erection.

[1]Address: 67 Dale St., Liverpool, England.

## ENGINEERING COLLEGES AND THE WAR

BY FRED H. RINDGE, JR.[1]

"When a professor of zoology is called from his recitations to advise the war authorities on armor for soldiers" says Frank Fackenthal, secretary of Columbia University, "the climax in college opportunity in the war has been reached." No less startling is the remarkable rapidity with which the engineering schools in the country, immediately on the declaration of war, placed their resources at the disposal of the Government. Many professors and students, of course, immediately went into actual service in various departments of the Government, Army or Navy. Many who remained began to serve the nation directly through mechanical, chemical, physical and other experiments of great scientific and war value. Most significant of all was the immediate readaption of various college curricula to include military drill, first-aid, etc. Specialized courses were organized in military aeronautics, military history and strategy, field engineering, map reading and sketching, military organization, and administration. Such colleges as the University of Illinois, Cornell, and Princeton organized aviation schools. Splendid wireless courses were organized at Harvard and ordnance courses at the University of Pennsylvania. A number of college students, in uniform, are taking a special military or naval course after which they have reasonable hopes of passing examinations that will result in their securing commissions. Columbia University has a special United States Navy gas-engine school (from which more than seven hundred men have entered into service since last June) and also a school of military cinematography.

The recent order from Washington permitting the engineering students in good standing to complete their courses before entering government service will greatly help the situation among the students in the engineering schools. Meanwhile, students have been encouraged to remain in school by such advice as the following from the Bureau of Education: "Engineers are needed in every important military operation, in transportation, in communication, in most of the supporting industries. The chemist and physicist are in greater demand than ever before both at the front and behind it." President Wilson has said: "It would seriously impair America's prospects of success if the supply of highly trained men were unnecessarily diminished. There will be need for a larger number of persons in the various fields of applied science than ever before. I have no hesitation in urging colleges and technical schools to maintain their courses."

In view of this, it is particularly important to have carefully planned engineering education. Students must be encouraged to complete their courses and, should be aided in doing so by the Government. The curriculum must include something besides technique; a large place must be given to the human side. Industry and the war demand engineers and officers who can handle men as successfully as they can handle materials. To help train men in this sort of thing, it is important that engineering students occasionally take time to study industrial conditions and human relationships and engage in practical service with the types of men with whom they will deal after graduation. One good plan would be for engineering students to spend one or two evenings a week, for example, teaching English or citizenship to a class of foreigners; or they might lead a group of American workingmen in mathematics, mechanics, or some other technical subjects; or handle a group of working boys in a club; or engage in other kinds of industrial service. How many of the engineering inspection trips that are regularly planned by most of the engineering colleges include an inspection of the human side of the industries visited? How much human engineering material is included on college bulletin boards or in their libraries? More important still, to what extent are professors actually including instruction in the human side in regular or special courses?

Now as never before it is necessary to train engineers who can understand the other fellow's point of view, and the other fellow is, in large measure, the working man. The engineering schools must produce leaders who, with this understanding, can help bridge the gap between capital and labor. They must produce men who realize that the interests of capital and labor are essentially identical and who can mold all their dealings with both great parties in industry with this clearly in mind. If we are to win this war there must be less misundertsanding and more cooperation in industry. No man is more strategically situated than the engineer who can look both ways, can understand both points of view, and can promote both cooperation and democratization in American industry. In the future, engineering schools will be expected to produce men with ideas and ideals who will help solve these vital and fundamental problems.

[1]Address: 124 E. 28th St., New York City.

* * *

## MACHINE PARTS SENT BY EXPRESS

The Express Traffic Association, composed of all the large express companies in the United States and Canada, have issued a statement relating to the marking requirements for express matter that is of considerable importance to the machinery trade. The regulations relating to castings, machine parts, shafting, pipe, rods, bars, and other metal articles are as follows:

1. When boxed, barreled, crated, or trussed, the container must be marked with pen, brush, stencil, waterproof crayon, or by label securely attached with glue or equally good adhesive.

2. When not boxed, barreled, crated, or trussed, and there is sufficient smooth surface for the purpose, the address must be plainly marked on the article with durable paint. Such shipments must not be accepted unless marks are thoroughly dry.

3. When not boxed, barreled, crated, or trussed, or when not possible to mark as provided in preceding paragraph, shipments must be marked with not less than two wooden, leather, metal, cloth, rope stock or sulphite fiber-tag-board tags. Rope stock or sulphite fiber-tag-board tags must test not less than 14 point, 50 per cent rope, have reinforced metal eyelets and must be attached by wire not less than No. 23 gage, or strong tarred cord. Tags must be attached wherever possible to unexposed parts of the article in order that they may not become detached in handling.

4. Rods, shafting, bars, pipe, iron bed sides, automobile springs and other articles of like character marked with tags as provided in Paragraph 3 must have the tags securely wired to the article, and, in addition, a concealed tag, bearing the same address, must be bound to the article with burlap covering, the latter securely wired at each end.

5. When metal articles are shipped in sacks, the address must be shown on the tag conforming to the specifications in Paragraph 3, attached either by wire or strong cord, and an additional tag bearing the same address must be enclosed in the sack.

It is of importance that these regulations be adhered to, as the express companies will not receive for transportation packages not so marked. A representative of the Express Traffic Association stated that there are today 75,000 metal articles in the warehouses in New York City alone which cannot be forwarded to their respective addresses because of insecure tagging or insufficiently clear marking.

* * *

## MARCH MEETING OF A. S. M. E.

The March meeting of the New York Section of the American Society of Mechanical Engineers, held at the Engineering Societies Building, 29 W. 39th St., New York City, Tuesday, March 19, was devoted to the subject of "Terminal Facilities of New York," and dealt specifically with the development of land and water terminal facilities, existing deficiencies and their correction, and agencies necessary in the future solution of the terminal problem. The subject was attacked from a number of different points of view, speakers representing the harbor authorities, the railways, the dock companies, the governmental commissions for relieving terminal congestion, and the several engineering fraternities, each presenting their views in brief statements. The purpose of the meeting was to secure practical suggestions and a method of applying them to the solution of present and future problems concerning the Port of New York. The subject is of the greatest importance to all the industries of the whole nation, inasmuch as one-half of all the import and export trade of the nation passes through the Port of New York.

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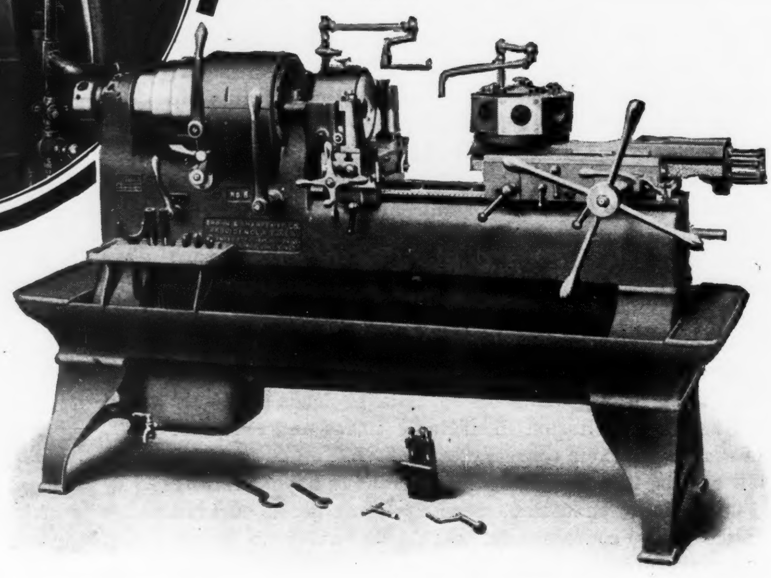

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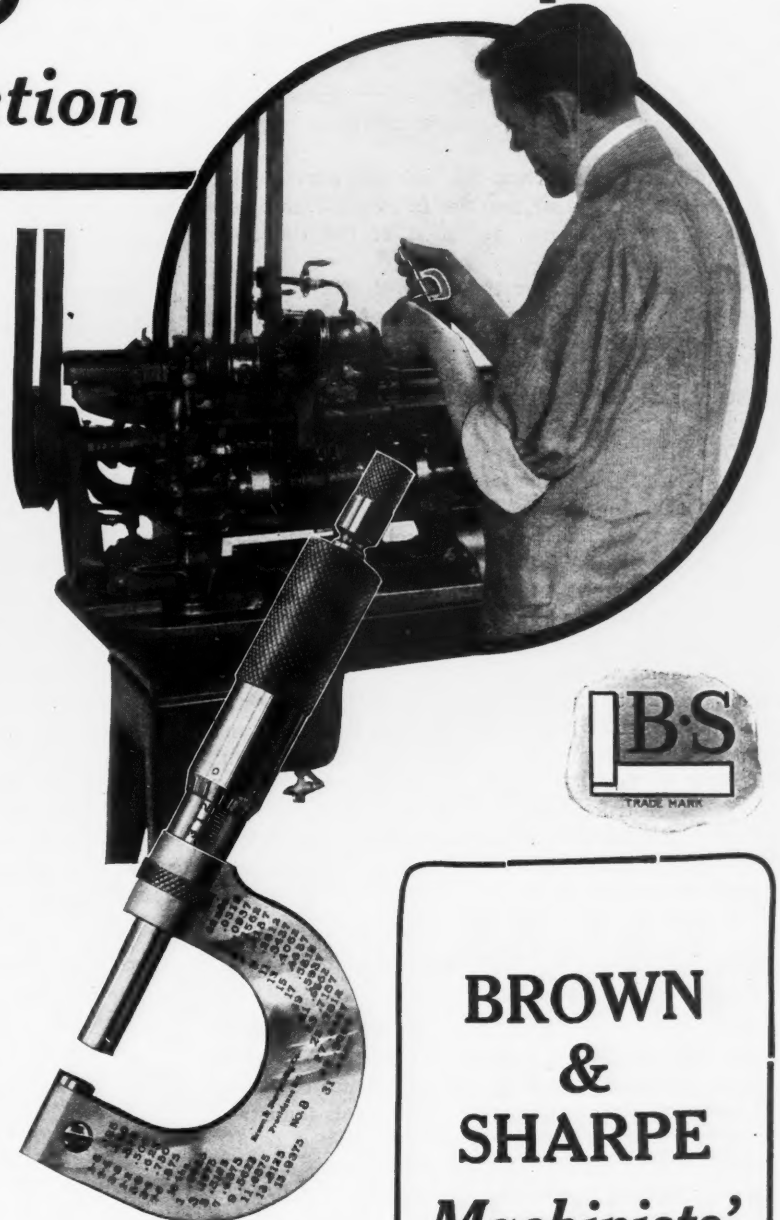

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## ESTABLISHMENT OF MUNITION DISTRICTS

In order to bring about decentralization and closer contact with munition manufacturers, General Wheeler, acting chief of the Ordnance Department, has divided the country into ten munition districts. The Boston district comprises the states of Maine, New Hampshire, Vermont, Rhode Island, and the eastern part of Massachusetts; the district chief is Levi H. Greenwood, of the Wakefield Rattan Co.

The Chicago district comprises the states of Illinois, Wisconsin, Minnesota, and that part of Indiana north of Warren, Tippecanoe, Clinton, Howard, Grant, Blackford, and Jay counties; the district chief is E. A. Russell, vice-president of the Illuminating Co.

The Cincinnati district comprises the southern parts of Ohio and Indiana; the district chief is Charles L. Harrison, of the Cincinnati Chamber of Commerce.

The Cleveland district comprises the northern part of Ohio and Erie, Crawford, and Mercer counties in Pennsylvania; the district chief is Samuel Scovil, president of the Cleveland Otis Elevator Co.

The Detroit district comprises the state of Michigan; the district chief is Fred J. Robinson, president of the Lowrie & Robinson Lumber Co.

The New Haven district comprises the state of Connecticut and the western part of Massachusetts; the district chief is Waldo C. Bryant, president of the Bryant Electric Co.

The New York district comprises that part of New York state south of Rensselaer, Albany, Schoharie, and Delaware counties and that part of New Jersey north of Mercer and Ocean counties; the district chief is Samuel G. Allen, chairman of the Lima Locomotive Works.

The Philadelphia district comprises the eastern part of Pennsylvania, the southern part of New Jersey, and all of the state of Delaware; the district chief is John C. Jones, of the Harrison Safety Boiler Works.

The Pittsburg district comprises the state of West Virginia, the western part of Pennsylvania, except Erie, Crawford, and Mercer counties, and Belmont and Jefferson counties in Ohio; the district chief is Ralph M. Dravo, member of the firm of Dravo Bros. steel constructors.

The Rochester district comprises all of the state of New York not contained in the New York district; the district chief is F. S. Noble, of the Eastman Kodak Co.

* * *

### CONSERVATION OF SKILLED LABOR BY THE ARMY

In regard to the second draft, Provost Marshal General Crowder says that men will be inducted into the service in very small groups from week to week or from month to month, as they can be assimilated by the Army. The whole industrial and agricultural situation is being carefully studied to discover any means that may be taken to protect and augment the labor supply without precluding the prompt and orderly progress of the military plans. As the need of the several armed forces for men highly skilled in technical and mechanical pursuits is greater than in any former war, the necessary numbers of such skilled men will be obtained first by assigning men already in the military service who have special skill to staff organizations and departments where their skill is needed. Men classified by the selection board, though they may have been placed in a deferred classification, will be withdrawn with great care from the industries of the nation for special service in staff corps and departments. Besides, young men of draft age with certain technical qualifications, will be inducted into the service and sent to universities, colleges, technical and secondary schools to be instructed in technical arts until they have acquired such proficiency as will justify their assignment to the special units. Ten thousand skilled artisans and as many young men graduates of grammar schools, will be sent to various technical and other schools throughout the United States for a two months' course of training. Thereafter, an increasing stream of selected men will be sent to educational and other training institutions for this purpose.

## HELPING UNCLE SAM

The U. S. Civil Service Commission has announced an open competitive examination for appointment to the positions of architectural, mechanical, and structural steel draftsmen, for ship work. Full information and application blanks may be obtained from the U. S. Civil Service Commission, Washington, D. C.

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The aviation section of the Signal Corps of the United States Army requires immediately 10,000 machinists, mechanics, chauffeurs, and other skilled workers. Men registered in the draft may volunteer for this service by applying to their regular local draft board. Men not registered may enlist at a recruiting office. Further information may be had by applying to the Air Division, Personal Department, Washington, D. C. Men accepted will be sent to San Antonio, Tex., where they will be given a brief course of instruction at the flying fields. They will also be sent to the various factories making aircraft, and will be organized into squadrons mostly for overseas service. The present call is especially for machinists, automobile and engine repairmen, gunsmiths, blacksmiths, tinsmiths, electricians, coppersmiths, sheet-metal workers, wireless operators and constructors, welders, and makers, repairers, and installers of magnetos, ignition systems, watches and clocks, instruments, and typewriters.

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Civilian workers are wanted by the Ordnance Department as inspectors on ammunition of different classes, as metallurgical chemists, as assistant inspectors on motor vehicles, and as engineers and assistant engineers for testing ordnance materials. These men should have a high-school education, some shop training, and a natural ability to adapt themselves to new work. Those who have the required technical training will be placed and advanced as quickly as their ability justifies. Machinists who are accustomed to accurate machine work are also required. The positions are under the Civil Service regulations, but the applicants will not be required to report for examination at any place. They will be rated in accordance with education and general experience. Applications should be directed to C. V. Meserole, Special Representative of the Ordnance Department, Room 800, 79 Wall St., New York City.

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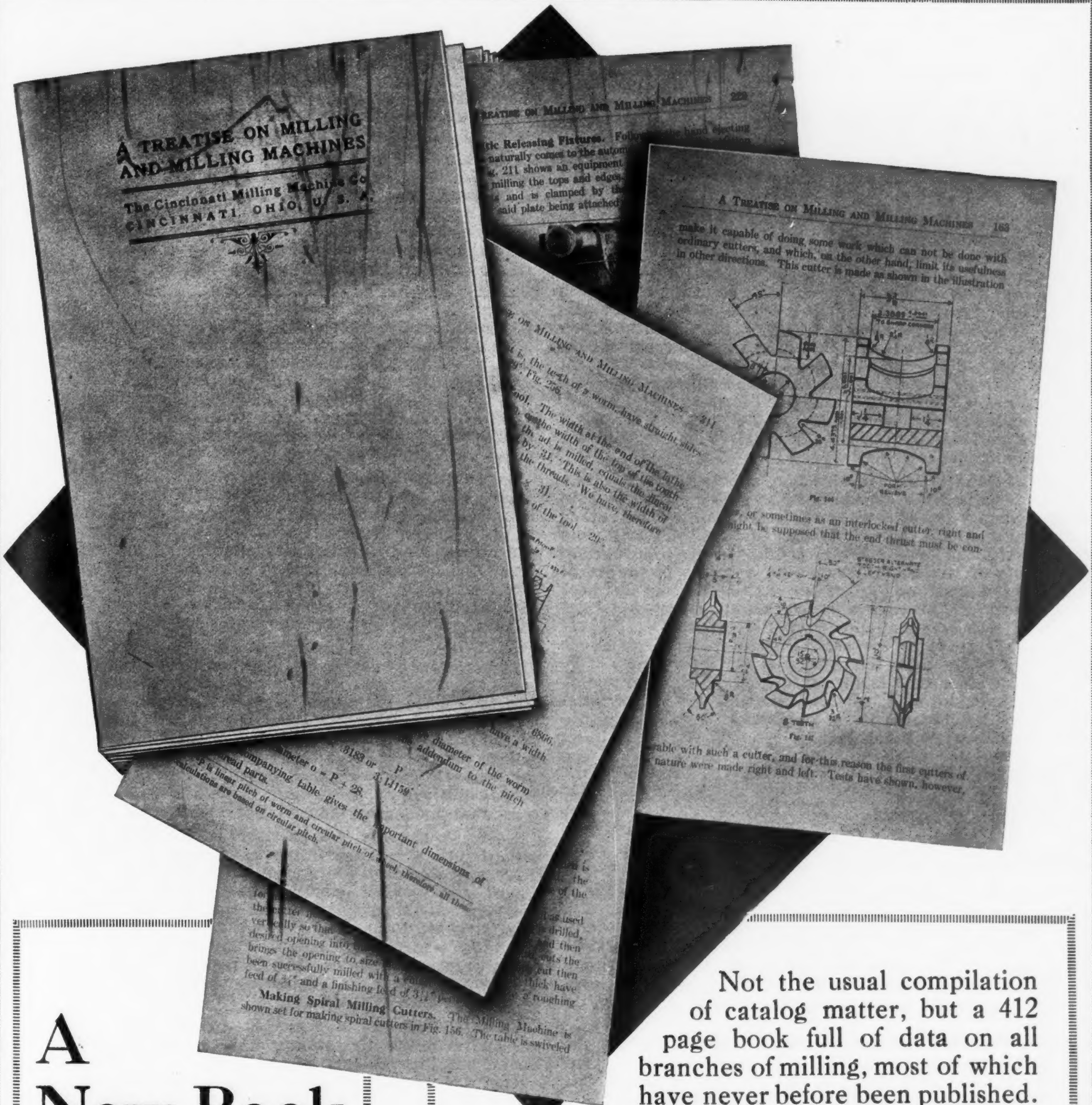
It may be of interest to the readers to know that MACHINERY has received a great number of letters from the various Governmental departments expressing appreciation of the cooperation that MACHINERY has given the Government by the publication of reading notices and advertisements relating to Governmental activities. As the service is finally rendered through the readers of MACHINERY themselves, we believe that it will be of interest to them to reproduce the following letter received from the National War Savings Committee, Treasury Department, Washington, D. C., which is but one of many similar communications.

> We hasten to acknowledge with thanks the very interesting advertisement which appeared in your issue of March devoted to the United States Shipping Board and the National War Savings Committee.
>
> You may be sure that the Committee is fully appreciative of this valuable cooperation, which we feel sure will reflect itself in assisting both the Shipping Board and this Committee. It is just such cordial and patriotic assistance as is manifested by this contribution that is making the War Savings Campaign throughout the country such a great success.

* * *

The great saving that is made possible by standardizing designs is well exemplified in the new motor truck designed by the Quartermaster Corps for the United States Army. In addition to being used as a war truck for army supplies in the Quartermaster Department, it will also be used by the Medical, Signal, Ordnance, and Marine Corps, by the Navy Department, by the Bureau of Docks, and by the Post Office Department. In addition, when fitted with a passenger body, it may be used as a passenger car for the use of army officers.

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## OBITUARIES

Frank J. Hurley died at the home of his parents in East Orange, N. J., March 10, after a long illness, from Hodgkins disease, aged twenty-nine years. Mr. Hurley was well known in the pneumatic tool field, having traveled for a number of years from the New York office of the Independent Pneumatic Tool Co.

Colonel Edwin A. Stevens died February 8 in the Providence Hospital at Washington, D. C., where he was serving as a shipyard inspector. He was born in Philadelphia, March 14, 1858. In 1879 he graduated from Princeton University, and later entered the Stevens Institute of Technology, which was founded by his father, graduating with the degree of M. E. Colonel Stevens was the designer of the *Bergen*, the first screw propeller ferry boat. Many other inventions of a mechanical nature are credited to him. He was at one time vice-president of the American Society of Mechanical Engineers and vice-president of the Society of Naval Architects and Marine Engineers, and was also a member of the Institute of Naval Architects in Great Britain. He is survived by his wife, six sons, and one daughter.

William Sloane Accles, for more than twenty years European manager for the Niles-Bement-Pond Co., New York, died in London, January 26, aged sixty-one years. Mr. Accles served his apprenticeship at the Colt Works, in Hartford, Conn., and was later with the Pratt & Whitney Co. He was a member of the Institute of Mechanical Engineers, a Fellow of the Royal Geographical Society, and a member of the American Chamber of Commerce. Mr. Accles was widely known and greatly liked by railway men and manufacturers all over Europe, having devoted many years to the cultivation of personal relations with buyers of the tools manufactured by his company. Besides the business friendships which he acquired over this period of years, he also had interests and a wide personal acquaintance in other fields, as is indicated by the organizations of which he was a member.

## PERSONALS

Sidney Diamant, 60 W. 129th St., New York City, has withdrawn his financial and other interests from the DeMant Tool & Machine Co., 79 E. 130th St., New York City.

Joseph Utz, formerly with Marshall-Huschart Machinery Co. of Indiana, has taken a position as salesman with the Federal Machinery Sales Co., 14 N. Jefferson St., Chicago, Ill.

J. B. Howell of the Sales Department of the Bound Brook Oil-less Bearing Co., Bound Brook, N. J., has entered active service in the United States Army, and is now in training at Camp Dix.

Herman Weyrauch has been appointed superintendent of the works of the American Spray Co., at Elizabethport, N. J. Mr. Weyrauch was formerly with the Babcock Printing Press Co., New London, Conn., and with R. Hoe & Co., New York City, for sixteen years.

W. H. Thompson, for many years prominent in the heavy electric traction work of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has resigned to take the position of works manager with the Fairmont Mining Machinery Co. of Fairmont, W. Va., makers of coal mining equipment.

Claude H. Davies has assumed the management of the general publicity for S. F. Bowser & Co., Fort Wayne, Ind. Mr. Davies has been connected with the company for twelve years, and during the past two years has been managing the New York district. His headquarters will be at the home office in Fort Wayne, where he will be in close touch with the general sales and publicity work of the firm in its entire field.

William T. Price has resigned as manager and chief engineer of the De La Vergne Machine Co., Oil Engine Department, to become president of the P-R Engine Co., Inc., New York City, and second vice-president of the Rathbun-Jones Engineering Co., Toledo, Ohio. The latter company will undertake the sale and manufacture of Price-Rathbun stationary and marine oil engines, which incorporate a method of fuel injection developed by Mr. Price.

Paul T. Irvin, who has been associated with the Wells Bros. Co. and the Greenfield Tap & Die Corporation, Greenfield, Mass., for twelve years, has resigned his position as sales manager of the Gage Division to become general sales manager of the Lincoln Twist Drill Co., Taunton, Mass., of which Edward Blake, Jr., formerly of Wells Bros. Co. is vice-president and general manager, and Frank O. Wells and Frederick H. Payne, president and vice-president of the Greenfield Tap & Die Corporation, are directors.

Herbert S. Lester, formerly with Manning, Maxwell & Moore, Inc., who volunteered in the 27th Division U. S. Army last June, has been commissioned Second Lieutenant, U. S. R., in the Ordnance Department, and assigned to active duty with the Engineering Bureau, Motor Equipment Section, Washington, D. C. Lieutenant Lester is an ex-member of the First Armored Motor Battery N. Y. N. G. and served as despatch rider for Adjutant General Stotesbury during the mobilization of the New York National Guard last spring.

L. S. Neuschul, managing partner of the Mett Engineering Co., Petrograd, who recently arrived from Russia, expects to be in this country about sixty days and will then return. He can be reached while here, at the company's New York office, 1 Madison Ave. Mr. Neuschul is optimistic about the future of Russia, believing that the good sense of the Russian people will in time assert itself, and result in a stable and progressive government; but he acknowledges that it will be some time before conditions approach normal. When they do, he expects a gradual but strong industrial development in his country.

Loyall A. Osborne, vice-president of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., and chairman of the Executive Committee of the National Industrial Conference Board, has been appointed by the Secretary of Labor a member of a committee on industrial peace during the war. This committee which consists of five representatives of employers, five labor leaders and two public men, will provide a definite labor program in order that there may be industrial peace during the war, thus preventing interruption of industrial production vital to the war.

Leon O. Hart has been elected treasurer and a director of the Driver-Harris Co., Harrison, N. J. Mr. Hart was graduated from Stevens Institute of Technology, and after graduation worked as a cadet engineer with the Public Service Gas Co. of New Jersey for about a year. He became associated with the Driver-Harris Co. as electrical engineer in 1908, and served in that capacity until March, 1917, when he was elected assistant treasurer. Mr. Hart is widely known throughout the electrical industries, and is a member of the American Electro Chemical Society and the American Society of Electrical Engineers.

## COMING EVENTS

**April 10-12**—Sixth annual meeting of the Chamber of Commerce of the United States of America, at the Congress Hotel, Chicago, Ill.

**April 18-20**—National Foreign Trade Council conference in Cincinnati, Ohio; Gibson Hotel, headquarters. Secretary, O. K. Davis, 1 Hanover Square, New York City.

**April 18-20**—Second annual convention of the American Gear Manufacturers' Association, held at Green Brier Hotel, White Sulphur Springs, W. Va. F. W. Sinram, care of Van Dorn & Dutton Co., Cleveland, Ohio, president.

**April 24-25**—Annual Convention of the National Metal Trades Association at the Hotel Astor, New York City. Homer D. Sayre, secretary, 1021 Peoples Gas Bldg., Chicago, Ill.

**April 25**—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

**May 15-17**—Joint convention of the National Supply and Machinery Dealers' Association, Southern Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association at Hotel Hollenden, Cleveland, Ohio. Secretary of the American Supply and Machinery Manufacturers' Association, F. D. Mitchell, Woolworth Bldg., New York City.

**May 16-17**—Spring meeting of the National Machine Tool Builders' Association at the Malborough-Blenheim Hotel, Atlantic City, N. J. Charles E. Hildreth, care of Whitcomb Blaisdell Machine Tool Co., Worcester, Mass., general manager.

**June 20-22**—Fifth annual convention of the American Drop Forge Association held at the Iroquoise Hotel, Buffalo, N. Y. E. B. Horne, "The American Drop Forger," 108 Smithfield St., Pittsburg, Pa., secretary.

**October 7-12**—Joint convention of the American Foundrymen's Association and the American Institute of Metals in Milwaukee, Wis. Concurrent with these meetings there will be an exhibition of foundry equipment, machine tools, and accessories.

## SOCIETIES, SCHOOLS AND COLLEGES

Grove City College, Grove City, Pa. Catalogue with calendar and courses of study for 1917-1918.

School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Bulletin for October, 1917, containing register of graduates and a list of the university men now in military service.

Polytechnic Institute of Brooklyn, College of Engineering, Brooklyn, N. Y. Catalogue 1918-1919, containing calendar and course of studies.

## NEW BOOKS AND PAMPHLETS

**Annealing of Carbon Steels.** By R. B. Fehr. 17 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the Pennsylvania State College, Harrisburg, Pa.

**Heat Transmission Through Building Materials.** By J. A. Moyer, J. P. Calderwood, and M. P. Helman. 9 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the Pennsylvania State College, Harrisburg, Pa.

**Purchasing Coal by Specification and Methods of Sampling.** By J. A. Moyer and J. P. Calderwood. 19 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the Pennsylvania State College, Harrisburg, Pa.

**Empirical Method of Analysis of Coal—Dry and Wet Coal in House Heating Boilers.** By J. P. Calderwood and J. J. Light. 25 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the Pennsylvania State College, Harrisburg, Pa.

**Percentage of Extraction of Bituminous Coal with Special Reference to Illinois Conditions.** By C. M. Young. 173 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as Bulletin No. 100.

**Electric Pumping with Results of Tests and Operating Records.** By H. W. Wagner. 80 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin No. 46.

**Broaches and Broaching.** By Ethan Viall. 221 pages, 6 by 9 inches; 187 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $2.

This book is compiled mainly from articles relating to the subject of broaching that have appeared from time to time in the "American Machinist," and contains a variety of information on the subject. It is divided into seven distinct sections, one dealing

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with broaching and broaching tools in general, and another with standard types of broaching machines. The other sections take up, in order, examples of pull broaching work and practice, push broaching work and practice, the design of pull broaches, the design of push broaches, and the making of broaches. In view of the interest in information on the subject of broaching and broaches, it is likely that many toolmakers will find suggestions of value in this book.

**Horizontal Cylindrical Tank Gaging.** By J. B. Morrow. 68 pages, 4¾ by 7¼ inches. Published by S. O. Spencer, Oakland, Cal. Price, $10.

This book presents in convenient form rules, tables and explanations by the use of which the contents of horizontal cylindrical tanks may be computed and tabulated. The method introduced in this book is very simple; only one basic table is needed for accurately finding the contents of horizontal cylindrical tanks of any diameter and at any level, whether the heads of the tanks be bulged or flat. The method is based on ratios or percentages, and therefore the results may be obtained with equal ease in any unit of volume. The book should be of especial value to anyone who has use for formulas and tables for quickly and accurately determining the volume of partially filled horizontal cylindrical tanks. In addition to the information applicable to problems of this kind, the book contains a number of miscellaneous problems and examples, as, for example, car tank dome capacity, computation of the capacity of the compartments of a wagon tank, etc.

**American Lubricants.** By L. B. Lockhart. 236 pages, 6 by 9 inches; numerous illustrations and tables. Published by the Chemical Publishing Co., Easton, Pa. Price, $2.

This book has been prepared from the standpoint of the consumer, and is intended as an aid to the user and buyer of lubricants. Throughout the book information of value to the user rather than to the refiner is given, making it possible for the former to select oils and greases intelligently. The book covers a wide field, and for convenient reference is divided into twenty-seven chapters, having, in addition, a section of viscosity, Baume gravity, and other useful tables. The field covered by the book is best indicated by the chapter headings which are as follows: Crude Petroleum; Refining of Petroleum; Refined Products; Friction and Lubrication; Lubrication of Internal Combustion Engines; Automobile Lubrication; Lubrication of Electrical Machinery; Lubrication of Steam Cylinders and Steam Engines; Lubrication of Steam Railways; Lubrication of Cotton Mills and other Textile Mills; Lubrication of Miscellaneous Plants and Machines; Physical Methods of Testing Lubricating Oils; Chemical Methods of Testing Lubricating Oils; Lubricating Greases; Methods for Testing and Analysis of Greases; Animal and Vegetable Oils; Methods of Testing Fatty Oils; Specifications for Fatty Oils; Specifications for Cylinder Oils; Specifications for Special Engine and Machine Oils and Car Oils; Specifications for Cutting Oils; Specifications for Greases, Graphite, Boiler Compound, and Cotton Waste; Specifications for Burning Oils; Specifications for Gasoline and Fuel Oil; Gasolines; Kerosene; and Tables.

## NEW CATALOGUES AND CIRCULARS

**Foster Machine Co.**, Elkhart, Ind. Catalogue containing detailed description of Foster countershafts of the friction clutch type, and tables of dimensions.

**Ibsen & Co.**, 404 Keefe Ave., Milwaukee, Wis. Bulletin of I. & C. gage standards which are made in sets of any desired combinations varying by steps of fractions of inches or millimeters.

**N. Y. Revolving Portable Elevator Co.**, 343-351 Garfield Ave., Jersey City, N. J. Calendar for 1918 showing pictures of the "Revolvator" in use piling bales, loading trucks, piling in freight cars, etc.

**Swan & Finch Co.**, 165 Broadway, New York City. Circular entitled "Solving that Difficult Machine Problem," treating of the lubrication of machinery and of the characteristics of "Slo-Flo" lubricant in particular.

**U. S. Smelting Furnace Co.**, Belleville, Ill. Circular of a new non-crucible smelting furnace which is claimed to be a cost-reducer for brass foundries. The furnaces will be built in various sizes, having capacities of 200, 500, 1000 and 2500 pounds.

**Bruno Mfg. Co.**, 61 Terrace, Buffalo, N. Y. Circular descriptive of the Bruno slotting attachment for shapers and planers by means of which dies or jigs requiring internal machining of irregular form can be readily machined, as well as exterior surfaces.

**Nelson Tool Co., Inc.**, 781-783 E. 142nd St., New York City. Catalogue entitled "A Modern Die Making Plant" illustrating the die, jig, gage, hardening, grinding, inspection, and manufacturing departments of the plant, and examples of some of the dies made by the company.

**General Electric Co.**, Schenectady, N. Y. Circular 63951, descriptive of the Tungar rectifier for public garages and battery charging stations. The Tungar rectifier will charge from one to ten three-cell starting and lighting batteries at a six-ampere rate from an alternating-current supply.

**Krantz Mfg. Co., Inc.**, Brooklyn, N. Y. Circular 1585-A illustrating safety auto-lock switches intended for use on circuits wherever the ordinary knife switches may be applied. They are so designed that it is absolutely impossible to touch the live parts regardless of the position of the switch or of the door.

**Krasberg Mfg. Co.**, Chicago, Ill., who are specialists in the manufacture of all kinds of tools and do contract work of every kind, have removed from 412 Orleans St. to Lake Shore Drive and E. Ohio St. Their rapidly increasing business has demanded more space, and the new shops occupy four floors of a large, well-lighted, modern building affording 88,000 feet of floor space.

**Royal Mfg. Co.**, Rahway, N. J. Catalogue entitled "Producing the Fittest in Waste", describing Royal cotton waste which, it is claimed, has been so made as to be of uniform quality and to have the maximum of absorbency. The catalogue is illustrated with views showing the stacking, sorting and grading, mixing, pulling, screening, machining, inspecting, weighing, and baling.

**Parker Mfg. Co.**, Ann Arbor, Mich. Circular of Parker Morse taper and straight arbors, Morse taper shanks, and high-speed drill chucks. The drill chuck shanks are classified into groups according to the tapers in the back of the chuck. The names of chucks which are interchangeable on Parker arbors and the arbors and the groups to which they belong are tabulated to facilitate ordering arbors.

**Vulcan Engineering Sales Co.**, 1765 Elston Ave., Chicago, Ill. Catalogue 3, illustrating and describing Hanna pneumatic riveters. Particular attention is called to special machines to be used in fabricating structural shapes and forms for the shipbuilding program. Many designs for use in automobile plants, boiler, tank and locomotive shops are presented. The catalogue also includes tables giving capacities, dimensions, weights, etc.

**Oakley Machine Tool Co.**, Cincinnati, Ohio. Circular illustrating and giving specifications for the Oakley No. 2 universal cutter and tool grinder. The internal grinding attachment, surface grinding attachment, and gear-cutter grinding attachment, are also illustrated, and views are included showing the machine in use grinding parallel blocks, snap gages, flat forming tools, spiral mills, angular cutters, saws, taps, inserted-tooth mills, and other work.

**Rogers Fibre Co.**, 121 Beach St., Boston, Mass., have been incorporated with a capitalization of $2,500,000, and have taken over the business of the National Fibre Board Co., the Leatheroid Mfg. Co., and the Mousam Counter Co., manufacturers of leather products. The officers of the new corporation are Elliot Rogers, president; Louis Rogers, vice-president; Stephen Moore, treasurer; Eric O. Hallberg, assistant treasurer; and Leon B. Rogers, general manager.

**Cling-Surface Co.**, 1018 Niagara St., Buffalo, N. Y., manufacturers of belt preservatives, have issued a chart by means of which the loss due to slipping belts may be easily determined in dollars and cents. As the power loss due to slipping belts is one of the simplest losses to overcome, and as belts are used to such a great extent, it will pay to look into the losses due to this cause. The chart supplied shows the extent of the loss in a very graphic manner, and indicates how the annual coal or power bill may be reduced.

**Westinghouse Electric & Mfg. Co.**, East Pittsburg, Pa. Reprint of articles entitled "Electrically Heated Japanning Ovens," by C. F. Hirshfield, and "Heat Calculations for Baking and Drying Ovens," by Wirt S. Scott. These articles treat of general considerations of electric heating for japanning and drying ovens and outline a detailed method of calculation for the amount of heat required to raise the temperature of the work, of the supporting and carrying parts such as trucks, and of the ventilating air.

## TRADE NOTES

**Fulflo Pump Co.** have moved their main office and factory from Cincinnati, Ohio, to their new plant at Blanchester, Ohio. All future communications should be addressed to Blanchester.

**Amalgamated Brass Co.** have moved their main office and factory from Cincinnati, Ohio, to their new plant at Blanchester, Ohio. All future communications should be addressed to Blanchester.

**Cyril J. Bath & Co.**, Cleveland, Ohio, machinery dealers, have removed their offices from the Leader-News Bldg. to 721 St. Clair Ave., N. E., where a representative stock of machine tools is maintained.

**Cochrane-Bly Co.**, Rochester, N. Y., have broken ground for a large one-story brick addition to their present plant. This will give double the present floor space and facilitate the building of their universal die shapers and cutting-off machines.

**Westinghouse Electric & Mfg. Co.**, East Pittsburg, Pa., have removed their Arizona office from Phoenix to Tucson. The representatives of the company, J. H. Knost and W. G. Willson, will have headquarters in the Immigration Building.

**Long & Allstatter Co.**, Hamilton, Ohio, have purchased the buildings and grounds of the Bentel & Margedent Co., of Hamilton. The expansion of the works of the Long & Allstatter Co. was made necessary by the increasing demand for their power punches and shearing machinery.

**Westinghouse Electric & Mfg. Co.**, East Pittsburg, Pa., have leased the Baxter Stove Co., Mansfield, Ohio, for a period of years with the intention of consolidating at this plant the manufacture of their heating appliances now being carried on at some of the other Westinghouse plants.

**Westinghouse Electric & Mfg. Co.**, East Pittsburg, Pa., have recently secured the exclusive sales agency in the United States for Frankel solderless connectors, which are widely used for joining electrical wires and cables. The Westinghouse Electric & Mfg. Co. will also act as distributors of the Frankel testing clips.

**Ketzer Machinery Co.** have consolidated with W. H. Robinson & Co., exporters and importers of general material, whose offices are in the Real Estate Trust Bldg., Philadelphia, Pa., and have added a Machinery, Engineering and Hardware Department which will handle all exports and domestic problems for machinery. Paul R. Ketzer is manager of the new department.

**Westinghouse Electric & Mfg. Co.**, East Pittsburg, Pa., have moved the Pittsburg Service Department from its former location on Amberson Ave. to new quarters at 6905 Susquehanna St., in the Homewood district of Pittsburg. Express and freight should be consigned to East Liberty, Pa., via P. R. R. The Automobile Equipment Service Department has also moved to the new location.

**Greenfield Tap & Die Corporation**, Greenfield, Mass., on March 5 formally opened their new office building and shipping room and recreation building. The erection of these two buildings marks the complete amalgamation of the various units and divisions of the Greenfield Tap & Die Corporation in different parts of Greenfield. About five thousand persons visited the buildings during the afternoon and evening. Souvenir booklets describing the new buildings were distributed.

**Walter H. Wade**, 311 Atlantic Ave., Boston, Mass., manufacturer of bench lathes and special tools and equipment, has bought the name of the American Watch Tool Co., Waltham, Mass., together with the patterns, drawings, attachments, and accessories of the No. 3 bench lathe made by that company. He has also acquired the bench profiling machine made by the American Watch Tool Co. Mr. Wade will continue manufacturing these machines in his present factory in Boston.

**Betts Machine Co.**, Rochester, N. Y., will carry on the business formerly handled by the Betts Machine Co., Wilmington, Del., and continue to build this company's line of boring mills, slotters, planers, etc.; this line will be improved and additions will be made to it. A. H. Ingle, who is president and manager of the new Rochester concern, on February 1 bought the patterns, jigs, fixtures, and parts, as well as good will of the Betts Machine Co. of Wilmington. The business will be located in a new brick and concrete building which is being erected adjacent to the plant of the Bridgeford Machine Tool Works, of which Mr. Ingle is also president and manager.

**Fulton Steel Corporation**, 165 Broadway, New York City, announce that the officers of the company are: president, H. C. Beaver, formerly assistant to the president of the Allis-Chalmers Co. and general manager of the Bullock Electric Mfg. Co.; vice-president in charge of production, William B. Morrison, formerly of the MacIntosh-Seymour Co. of Auburn, N. Y.; treasurer and secretary, Safford A. Crummey; metallurgist, Irving R. Valentine; and superintendent, Clarence L. Cline, formerly with the Latrobe Electric Steel Co. and the Firth Sterling Co. The company occupies a main building 80 by 240 feet with crane runway extensions of an additional 320 feet, on which is operated a ten-ton Shaw crane. Plans are being made for the extension of the plant, which will give additional melting capacity up to 50 tons per day.

**Worthington Pump & Machinery Corporation**, 115 Broadway, New York City, have made the following changes in the personnel of the organization: James E. Sague has been made vice-president in charge of engineering and manufacturing. Leon P. Feustman has been made vice-president in charge of general commercial affairs, including contracts, prices, purchases, traffic, etc. Frank H. Jones has been made vice-president in charge of sales, and William Goodman has been made assistant to vice-president James E. Sague. William Schwanhausser has been made chief engineer. Edward T. Fishwick has been made general sales manager, and Charles E. Wilson, assistant general sales manager. Neil C. Lamont has been made works manager of the Laidlaw Works with office at Elmwood Place, Cincinnati, Ohio.

**Swan & Finch Co.**, 165 Broadway, New York City, manufacturers of special oils and greases, have recently celebrated their sixty-fifth birthday. The business was started in February, 1853 in a small building at 44 Water St., New York City, and it has grown until today the main plant at Bayway, N. J., covers over fifteen acres with piers at which tank boats and ocean-going steamers dock. The original business of the company consisted of the sale of illuminating oils and lubricants, including fish and animal oils, sperm and other whale oils, sea elephant oils, black fish and lard oils. At the present time 197 distinct oils and greases are manufactured. The entire development of the company has been along "service idea" lines. A corps of chemists and field engineers is maintained whose duty it is to analyze the needs of each customer and supply the special product required, and, where necessary, to develop new products to meet new needs.

**Whitman & Barnes Mfg. Co.**, Akron, Ohio, have made the following changes in their Sales Department: A. B. Hall, vice-president of the company, will have supervision of the company's sales. Mr. Hall has been connected with the company for the past twenty-one years in various sales and official capacities. His early connections were with the company's Chicago sales office as manager, which position he held until his transfer to the general office at Akron. R. S. Carter, district representative of the company, with headquarters in Pittsburg, has been promoted to the position of sales manager and will have direction of the twist drill and reamer sales from the general office. H. E. Fisher, formerly with the Pittsburg Model Engine Co., Pittsburg, Pa., will succeed R. S. Carter as mechanical engineer and will have charge of sales in the Pittsburg district. Paul E. Thomas of Chicago, who has been prominent for years in railroad circles in the traffic department of the Seaboard Air Lines, has been made sales manager of the company in charge of the department of wrenches and spring cotters.